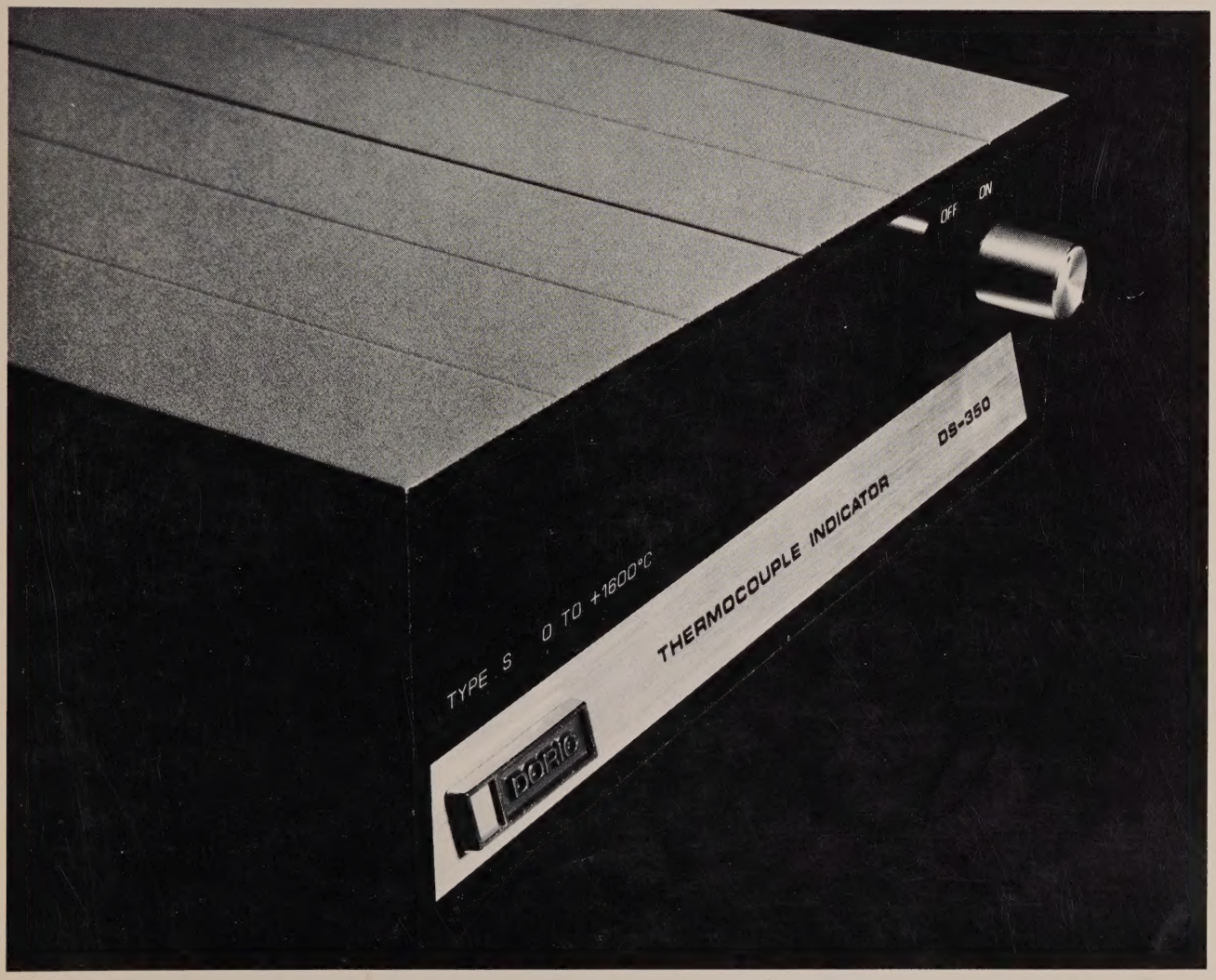
OWNER'S MANUAL



MODEL DS·350
DIGITAL THERMOCOUPLE INDICATOR

DORIC SCIENTIFIC CORPORATION

WARRANTY

Doric Scientific Corporation hereby warrants each instrument of its manufacture as follows:

1. At the time of delivery of each instrument to the original purchaser, Doric Scientific Corp. UNCONDITIONALLY WARRANTS that it shall be free from defects in parts, materials and workmanship; and

2. Commencing with the date of shipment of each instrument to the original purchaser, Doric Scientific UNCONDITIONALLY WARRANTS that each unit shall remain free from defect in parts, materials and workmanship for the period specified below.

In the event any instrument fails to meet the terms of this warranty, Doric Scientific Corp. agrees to provide corrective action. Refer to the Owner's manual for the proper procedure.

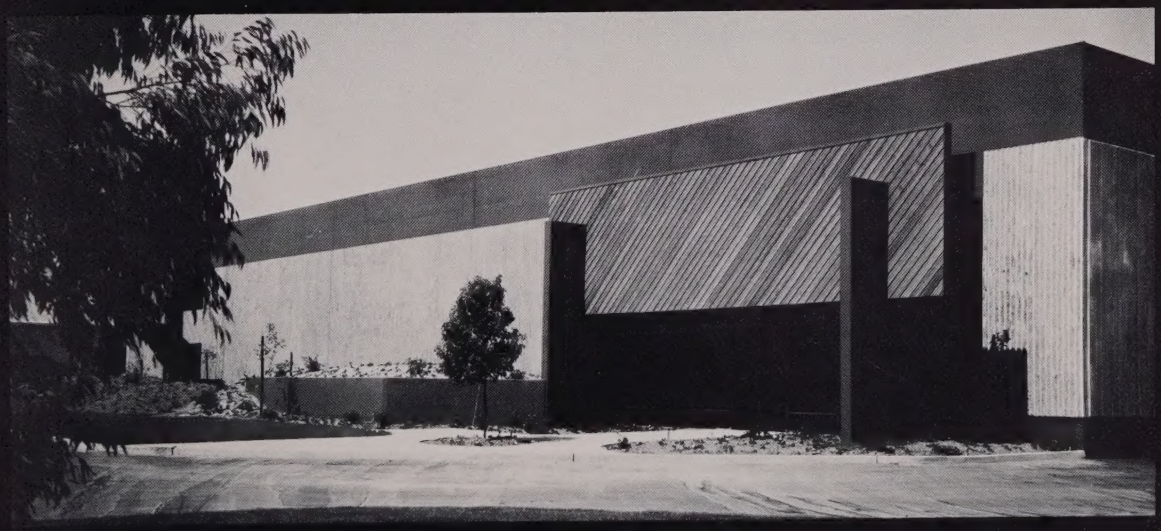
The warranties herein shall not obligate Doric Scientific Corp. in any manner whatsoever with respect to, and shall not be applicable to, any defects which after an inspection by Doric Scientific Corp. are not to Doric Scientific Corp.'s reasonable satisfaction demonstrably the result of defective parts, materials or workmanship. We are not liable for consequential damages.

5-Year Warranty:	DS100-K Series; DS100-P Series
2-Year Warranty:	DS100-T Series; DS300-T2; DS300-T3; DS305; DS350-T3
1-Year Warranty:	Digitrend Series; 215; DS330-T3; DS500-T3; DS520-T3; DS530-T3

For other manufacturer's equipment purchased through Doric, this corporation conveys the full warranty of the original manufacturer in respect to duration and degree of coverage.

CERTIFICATION

Doric Scientific certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when shipped from the factory. Doric Scientific further certifies that its calibration measurements are traceable to NBS.



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section 1

description

1.1 GENERAL DESCRIPTION

The Doric Scientific DS350-T3 is a fully automatic, solid-state measuring instrument which, after proper signal conditioning, displays the outputs of a wide variety of thermocouples directly in °F or °C.

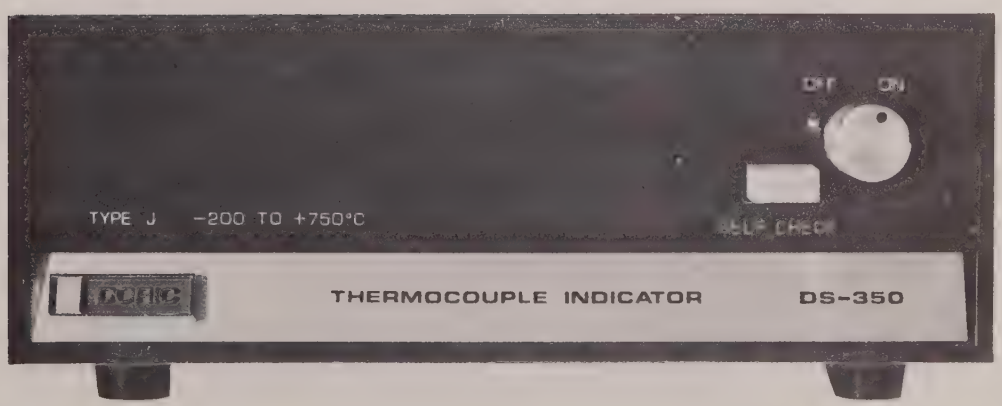


FIG. 1-1 DS350-T3

The instrument includes a microvolt level A/D converter; direct nixie display and internal reference junction compensation. Automatic thermocouple break detection is also standard.

The DS350-T3 is normally wired to operate from either 115 ±10% VAC or 230 ±10% VAC 50 - 400 Hz power source. Selection of operating voltage is made with SW2, mounted to the shield at the rear of the instrument and covered by the rear panel to prevent inadvertent operation. See 2.3 for voltage selection.

A .25 Amp SLO-BLO power fuse is used for 115V operation; a .125 Amp SLO-BLO power fuse for 230V.

Dependent upon full scale requirements, four or five high intensity nixie tubes form the inline readout, providing a sharp display of the digits and decimal point. Storage circuits hold the display constant between and during encoding, eliminating blanking, blurring and last digit flutter.

In the event that the instrument is being overloaded by an excessive voltage input, the nixie display will begin flashing and blurring. When the input level has been corrected, normal display will return.

If the thermocouple input has opened, the nixies will exhibit the same symptoms as an overload condition, making it impossible to read the display. Once the open is corrected, normal readout will resume.

A "—" symbol on the readout indicates the minus or negative polarity. Absence of the symbol indicates a plus or positive polarity.

The overflow "one" is a neon lamp.

A 2.5 Amp SLO-BLO Pigtail fuse, FS2, protects the I. C. Supply. This fuse is located on the mother board.

1.2 EXTERNAL CONTROLS

1.2.1 Power Switch

Power is applied to the instrument by moving the rotary switch located on the front panel from the OFF to the ON position.

1.2.2 Multipoint Pushbuttons

If the DS350 is purchased with option ISC-12, it will have a 1½" lower box permanently attached to the standard chassis. (See Figure 1-4.) This box houses the 12-channel switchboard on which are mounted 12 pushbuttons. Each button controls the selection of a particular thermocouple. Depression of a button selects that given thermocouple's temperature for display on the readout. (To disengage a pushbutton, push all the way in and release.) When two or more buttons

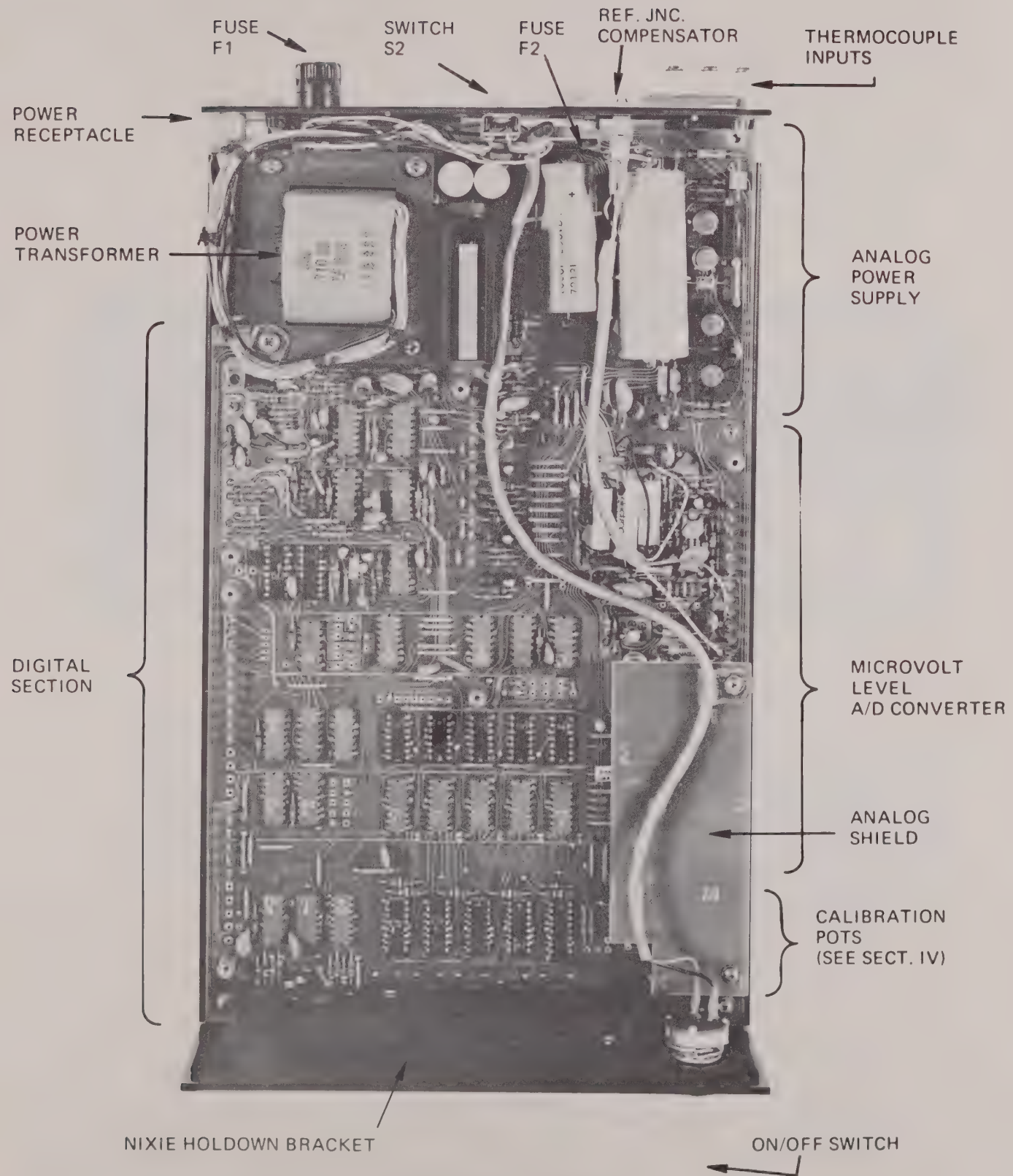


FIG. 1-2 PS350 BOARD ASSEMBLY

are depressed, the instrument will display the "average" temperature of all those thermocouples being measured.

If the DS-350 has the external 12 or 24 button option, the DS-350 will retain its 3 x 8.5 exterior dimensions. The pushbuttons will be housed in a separate 3 x 8.5 box. (See Figure 1-4.)

Wiring instructions for the multipoint selectors are described in Section II.

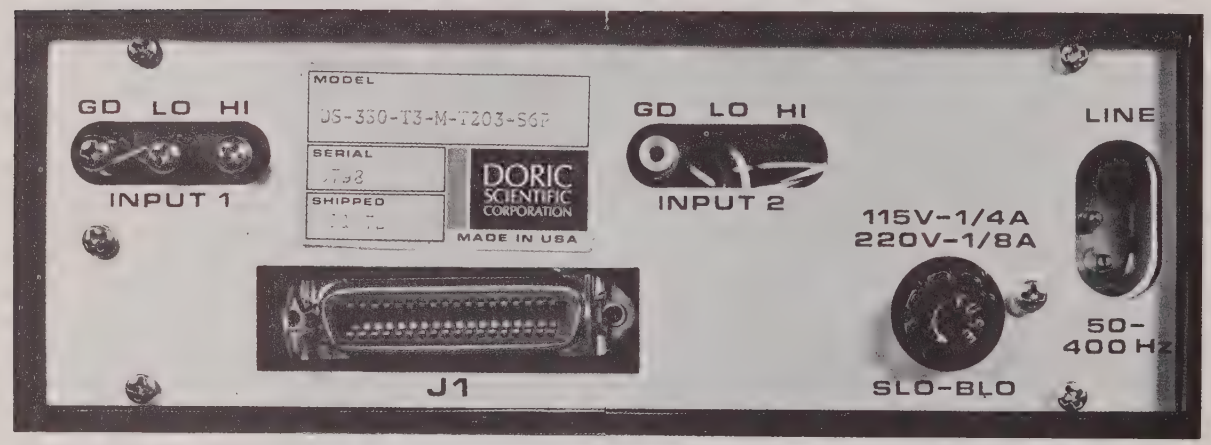


FIG. 1-3 DS350-T3 REAR PANEL & SLIDE SHIELD

1.3 BCD OUTPUTS (Option S6P)

When isolated BCD outputs are installed, they are brought to the rear of the instrument via a 36-pin Amphenol connector, J1. (See Section II for pin information.) These outputs enable the instrument to interface with external elements for system usage. Remote sample command and readout "hold display" inputs are included.

The BCD outputs are positive true unless otherwise specified at time of purchase.

(See Section II, Remote Programming for hookup and operation.)

1.4 INSTANTANEOUS BURN-OUT DETECTOR

If the measuring thermocouple burns out or comes open at any time before the encoding cycle, the read-out is immediately blurred and an overload indication (3V to 5V) appears at the BCD output on Pin J1-11.

FIG. 1-4 MULTIPOINT VARIATIONS

1.5 THERMOCOUPLE TRANSFER-STANDARD OPTION

This option transfers the high inherent accuracy of the DS-350 to other thermometers, recorders and controllers in the laboratory or field. An adjustable, internal floating reference source converts the DS-350 into a temperature transfer standard. Front panel control knobs activate the option and allow adjustment of the stable internal source which is measured and displayed on the instrument readout while simultaneously being applied to the unit being calibrated. The option is available with any TC type and range specified for the basic instrument and settability is limited only by the resolution of the instrument (.1° F or C). Instruments with input impedances as low as 1K ohms can be calibrated.

1.6 MICROVOLT DVM OPTION

Instead of thermocouple temperature readout, the same basic instrument can be supplied as a single range, very high performance ±19.999mv F. S. DVM at very low cost. Input impedance is greater than 100 megohms. Accuracy is ±.02% reading ±.01% F. S. ±2 microvolts, with repeatability better than ±2 microvolts. Useful for OEM's interested in low level with high performance. Also ideal for strictly low level lab work. With external ice bath, use this unit to calibrate thermocouples.

1.7 COMPENSATED MICROVOLT DVM

Same as microvolt DVM option, but with built-in reference junction compensation allows direct connection to thermocouples. Particularly useful for very precise thermocouple calibration applications with readout in precompensated millivolts, thus avoiding the slight linearization errors incurred in direct temperature readout. Ideal for the temperature metrology labs.

1.8 PEAK RETENTION — FOR MOLTEN METAL/GLASS INDUSTRIES

With simple digital comparator techniques, this accessory allows continuous measurement of temperature with the peak or maximum value retained in the display. A reset button removes the previously stored peak to allow start of a new test. A front panel selector, PEAK/TRACK allows normal temperature readout without peak storage. This feature is highly useful in molten metal and glass manufacturing. The same circuit can be supplied as a "Valley" detector (minimum) if desired. Being digital there is no drift or droop and the bandwidth or response time of the peak detector is only limited by the instrument digitizing rate, about 3 readings/second.

1.9 SELF-CHECK OPTION

The DS-350 Self-Check Option provides the customer with a quick functional check of the DS-350 system.

Depression of a Front Panel Pushbutton (see Fig. 1-5) disconnects the analog-to-digital converter of the DS-350 from the input thermocouple & reference junction and connects the converter to a precision internal reference voltage. A specific reading is displayed on the readout "Nixie" providing a quick check of system function. The self-check reading displayed on each instrument is designed to lie between 80% & 100% of full scale for the range specification ordered. To determine the proper self-check reading, turn on instrument and allow 30 minutes for warmup. Then depress self-check button. The reading displayed will be the reading that should be present on all future checks.

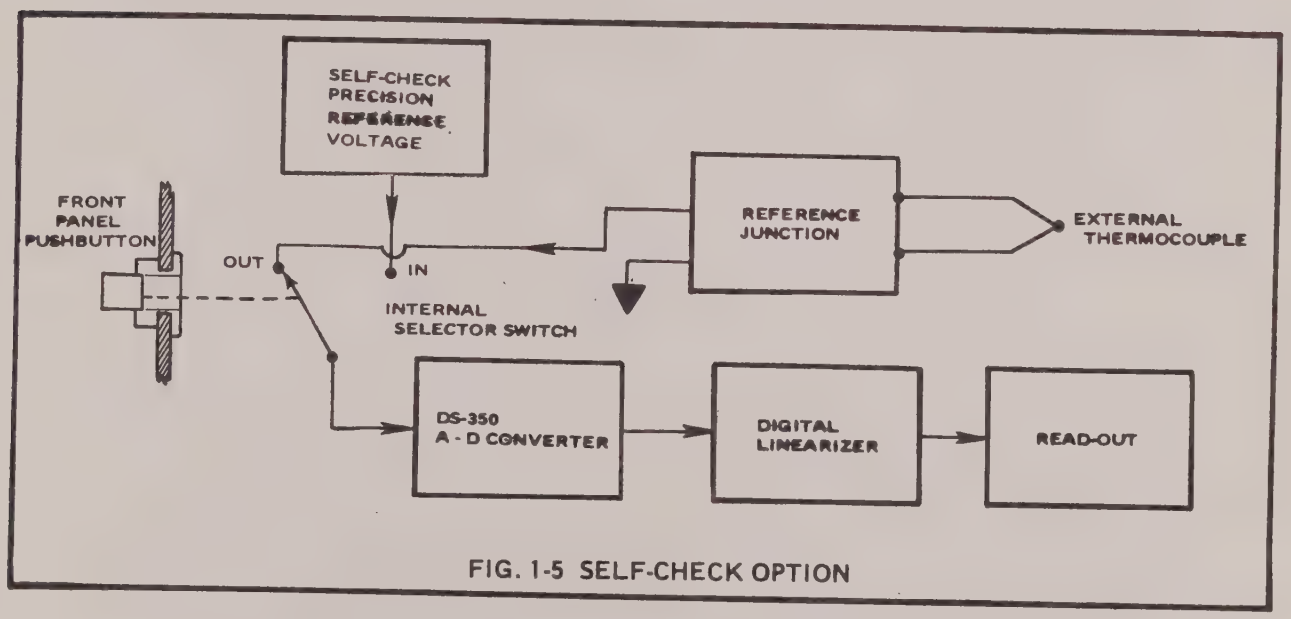


FIG. 1-5 SELF-CHECK OPTION

CAUTION

The Self-Check Option is a convenience feature only, to detect short term changes which may indicate instrument malfunction. The Option is not intended to supplant careful, periodic calibration of the DS-350 digital thermometer.

While great care has been taken to provide aged, stablilized components in both the precision reference sources of the main instrument & Self-Check Option, small changes over time will be

observed in the self-check reading — failure to observe such changes does not insure a current instrument calibration.

1.10 DIGITAL ALARMS, SINGLE & DUAL SETPOINT OPTIONS

High speed, drift free digital comparators provide exact determination as to when measured temperature exceeds preset limits, either high or low or both high and low. Alarms are set exactly to 0.1° via decimal indicating, thumbwheel switches. When a limit is exceeded, a front panel lamp lights and a closure is provided for external use. Either single or dual high-low options are mounted in a small accessory module, (same size as the indicator). Manual and remote reset are provided. This option can also be set up for dual high limit alarms. Closure ratings are 28VDC, 0.1 ampere.

When this option is included, a separate manual supplement is attached to the DS350 manual, explaining in detail, the workings of the alarm feature.

1.11 PERFORMANCE SPECIFICATIONS

Repeatability:

± 1 digit for 1 week

Resolution:

0.1° except on certain ranges as listed

Input Circuit:

Allows grounded T.C.'s even with unbalanced inputs and digital outputs grounded wirh no CMR degradation.

Measurement Method:

Automatic zeroing, dual slope true integration with no possibility of zero foldover errors; Ex/Eref switching in front of input preamplifier

Zero Drift With Time:

Absolutely none

Linearization:

Digital. Binary rate multiplier; 32 segment. Each segment to have 1 part in 511 resolution (9 digital bits)

Common Mode Rejection:

120db or better at all frequencies above 49Hz with 100 ohms unbalance, with or without cold junction; 250 VDC or AC CMV

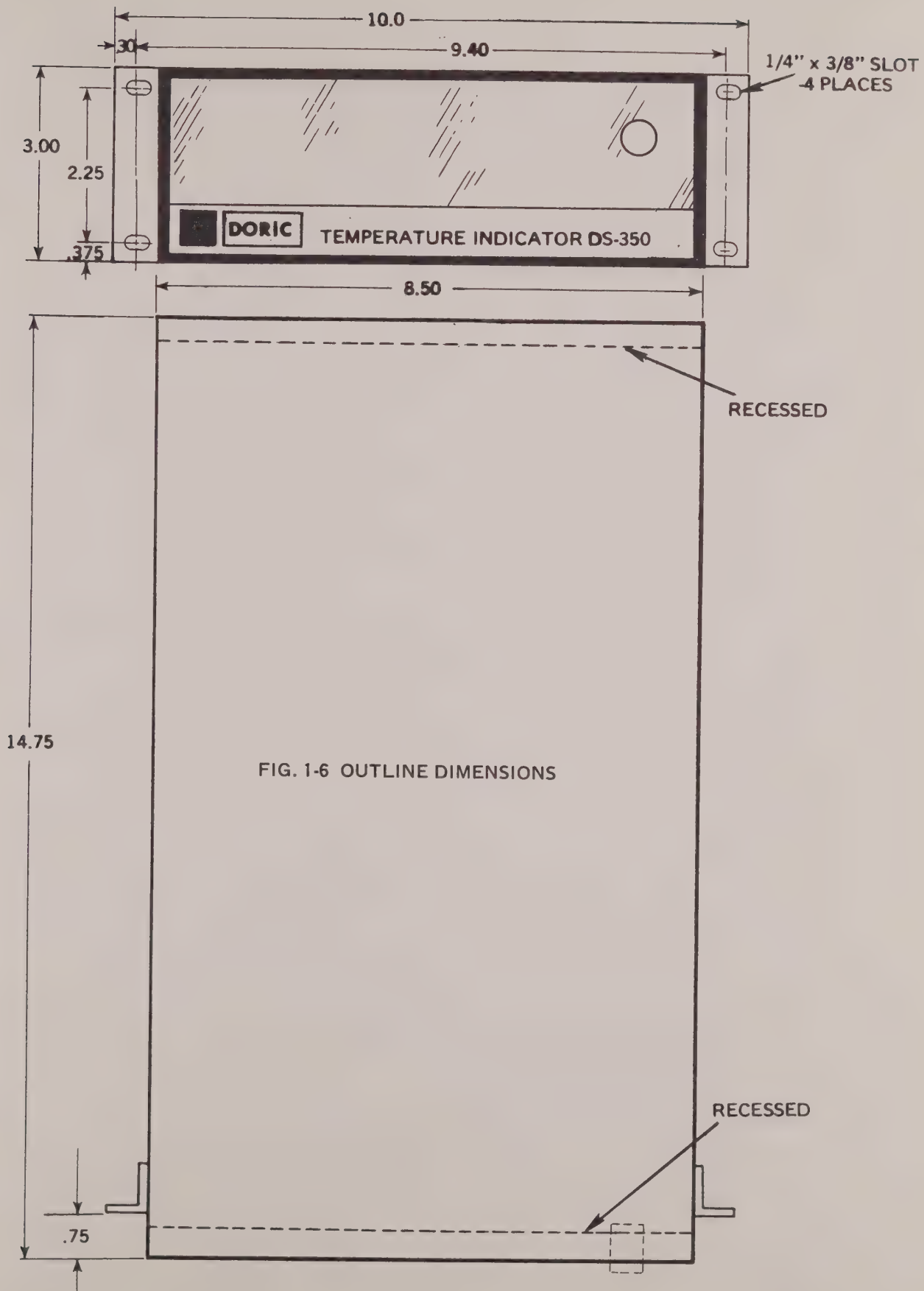


FIG. 1-6 OUTLINE DIMENSIONS

Temperature Stability: (not including cold junction) ±.003% rdg./°F, ±.025°F/°F for Types J. K. T. Y. E: Types R, S and B: ±.003% rdg./°F, ±.05°F/°F

Cold Junction Error:

No error at calibration ambient of 77 ±2°F; temperature effects of ∓.015°F/°F from 50 to 104°F, around midpoint, regardless of TC type

Temperature Transfer Standard:

Calibration accuracy same as basic instrument; settability equal to or better than resolution; floating reference source separate from digital indicator zener reference. Output load resistance to be 1000 ohms or greater.

Long Term Stability:

.01% RDG or ±0.1° per month max

.03% RDG or ±0.5° per year max.

Polarity:

Automatic with indication when negative.

Reference Junction Technique:

Ambient tracking type with silicon diode sensing of ambient and associated bucking network for precise compensation; bridge type not allowed.

Speed:

3-4 reading per second. Settable by resistor.

Response Time:

1 second to 0.1% from step function for any TC type.

Overload:

Accidental connection of 115 volt AC line across input will not damage.

Sensitivity:

1 microvolt, or 0.1°

Display:

Nixie indicators. Socket mounted. Storage to prevent blur.

Size:

Half-rack, 3 by 8.5 inch panel.

Calibration:

0 and full scale. For bipolar 0 and ± full scale. All potentiometers must be front accessible.

Calibration Data:

Included at no cost. Tables define worst case errors at 5° increments throughout the calibrated range.

T. C. Input Connections:

Screw terminals at rear. Easily handles 14 gage TC wire.

AC Power:

105-125 VAC, 50-400Hz, Optional 220V. 3-prong safety plug with enclosure at ground potential eliminates shock hazard.

Operating Temperature:

For normal accuracy from 50°F — 104°F; reduced accuracy from 0°C to 50°C. Most units available on special order ($) for use down to -40°C ambient.

Break Detection:

Detection within one complete measurement cycle (660 ms absolute max — 330 ms typical). Operates with up to 1500 ohms line impedance and .015 μF line capacity. Disconnectable at factory or in the field. Flash/blur of display for "open." Absolutely no derating in instrument accuracy with source impedance.

Source Resistance:

Nominal 1500 ohms ± 1 digit error, Types J, K, T, E; nominal 500 ohms for noble metals. These figures allow for exit current effects.

Normal Mode Rejection:

70db minimum at 60Hz. As an option, an active filter with field settable poles from 1Hz up is available.

Factory Changeable Type & Range:

Simple low cost retrofit can be accomplished when desired.

Warm-up Time:

Rated accuracy, typically ±0.5° within 10 seconds after turn-on, in normal in-plant type environments. Full accuracy within 30 minutes.

Humidity Protection:

The PC boards shall be masked and sprayed prior to component assembly.

Intrinsic Safety:

When used with standard Taylor barriers in a control room application, this instrument can be used with field mounted sensors.

Remote Hold:

Applying a closure between 2 rear panel pins will prevent the instrument from making a new encoding.

Basic Configuration:

Includes power cord, front panel power switch, tilt stand, screw terminal TC input, rubber feet.

Instrument Case:

Single piece, rugged, extruded aluminum case weighing at least 6 pounds without the electronics.

NBS Conformity:

Linearization conforms new NBS Nomograph #125 which supersedes NBS Circular #561.

Electronics:

Complete instrument mounted on plastic slides to allow easy removal from aluminum chassis. Only 2 screws required for removal.

Power Transformer;

Triple shielded power transformer. Weight of transformer supported by rigid metal guard plane and not by printed circuit board.

Packaging:

All components made by U. S. A. manufacturers. Axial lead components must be mounted horizontally (same plane as PC board) and not vertically. Computer grade electrolytics throughout. Plated-through holes are not allowable unless solid wire feed-throughts are used. Basic PC board shall be 3/32 inch thick glass epoxy.

Front Panel:

In addition to the AC power switch, labeling is provided listing the model number, TC type and measure range.

STANDARD RANGES

ANSI — ISA Type	Thermocouple Type	Temperature Range	# Of Segments	Resol.	Calib. Accuracy # Including Linearization & all other errors at 77 ± 5° F, ± 10% line voltage, for 24 hours, without zero or scale adjustment	Maximum Linearization Error (under any conditions) (Shown for academic purposes; see column to the left for honest overall accuracu guarantee)	Range Designator
J	Iron-Constantan	-320°F to + 800.0°F	32	.1°	±0.6°F, -320 to -300°F ±0.5°F, -300 to -200°F ±0.4°F, -200 to -100°F ±0.3°F, -100 to 0°F ±0.5°F, above 0°F	±0.27°F	J203
J	Iron-Constantan	0 to + 1600.0°F	32	.1°	±0.6°F	±0.24°F	J201
J	Iron-Constantan	-200.0°C to + 750.0°C	26	.1°	±0.55°C, -200 to -120°C ±0.28°C, -120 to 0°C ±0.34°C, 0 to + 540°C ±0.44°C, above + 540°C	±0.28°C	J202
K	Chromel-Alumel	-40.0°F to + 2400.0°F	33	.1°	±0.4°F, below 0°F ±0.6°F to -900.0°F ±0.9°F, 900 to + 1500°F ±1.1°F, 1500 to + 2040°F ±0.9°F, above 2040°F	±0.4°F	K201
K	Chromel-Alumel	-60.0°C to 1370.0°C	31	.1°	±0.2°C below 0°C ±0.4°c to + 1000°C ±0.5°C, above 1000°C	±0.19°C	K202
T	Copper-Constantan	-320.0°F to +750.0°F	32	.1°	±0.7°F, -320.0°F to 0°F ±0.6°F, 0°F to -750°F	±0.3°F	T201
T	Copper-Constantan	-160.0°F to + 480.0°F	32	.1°	±0.4°F below 0°F ± 0.3°F above 0°F	less than ± 0.1°F	T203
T	Copper-Constantan	-200.0°C to + 400.0°C	30	.1°	±0.5°C, -200 to -120°C ±0.35°C, -120 to 0°C ±0.2°C, 0 to 400°C	±0.17°C	T202
E	Chromel-Constantan	-280.0°F to 1800.0°F	32	.1°	± 0.7°F below 0°F ±1.0°F above 0°F	±0.58°F	E201
E	Chromel-Constantan	-220.0°C to 1000.0°C	31	.1°	±0.7°F below 0°F ±0.6°C above 0°C	±0.396°C	E202
R	Plat./Plat. 13% Rhod	0 to 3100°F	31	1°	±3.7°F below 600°F ±1.4°F above 600°F	±1.8°F below 600°F ±0.3°F above 600°F	R201
R	Plat./Plat. 13% Rhod	0 to 1600.0°C	32	.1° (or 1 μv)	± 1°C above 200°C ±1.5°C below 200°C	±0.32°C above 200°C ± 0.7°C below 200°C	R202
R	Plat./Plat. 13% Rhod	+ 640.0°C to + 1280.0°C	32	.1°	±0.5°C	± .064°C	R203
S	Plat./Plat. 10% Rhod	0 to 3200°F	32	1°	±3.3°F below 300°F ±1.8°F above 300°F	±1.6°F below 350°F ±0.5°F above 350°F	S201
S	Plat./Plat. 10% Rhod	0°C to + 1600.0°C	32	.1° (or 1 μv)	± 0.9° above 200°C ± 1.4° below 200°C	± 0.3° above 200°C ± 0.6° below 200°C	S202
S	Plat./Plat. 10% Rhod	+ 640.0°C to + 1280.0°C	32	.1°	b 0.5°C	±.072°C	S203 *

* Referred to newest NBS Tables, NBS Nomograph #125, (1 microvolt tables) and not including sensor error

section 2

installation

2.1 UNPACKING

Because of the ruggedized construction of the DS350-T3, little need be done to insure that the instrument has arrived free of shipping damage.

A cursory visual inspection of the instrument's exterior should be accomplished immediately after unpacking it from its shipping container. If obvious damage is evident, both the shipping agency and Doric Scientific should be notified as soon as possible.

If the DS350-T3 shows no signs of damage, a quick electrical test can then be performed to insure that the instrument is operative. By shorting the HI and LO terminals on the rear panel together and applying power to the instrument, the readout should display the approximate ambient temperature. If the readout displays the approximate figure, it may then be hooked up to the user's application.

NOTE: The thermocouple input must either be shorted or attached to a thermocouple. An open input will cause the break detect circuit to activate, which will result in the readout blurring.

2.2 REPACKING; RETURNING THE INSTRUMENT

If it is at all feasible, the original shipping container should be retained in the event reshipment of the instrument becomes necessary.

If the DS350 must be returned at any time to Doric for repair, modification, etc., insure that it is properly cushioned and packed and that a list of symptoms or work to be accomplished accompanies the instrument.

(Return the DS350 prepaid. Doric will, in turn, pay the freight charges when returning the unit to you.)

2.3 INSTRUMENT HOOKUP

Unless specifically ordered otherwise by the customer, the DS350 comes set to operate from 115 VAC, 50 - 400 Hz. For 230 VAC operation, remove the rear panel of the instrument by removing the six Filister head screws. Set Selector Switch SW2 (mounted on shield) to the "230V" position. Replace the panel & screws. Change Fuse FSI to 1/8 amp, SLO-BLO.

2.3.1 Grounding Considerations

For noise-free operation, the measuring circuit should be connected to earth ground at one and only one point:

a. If the thermocouple is grounded, the circuit shown in Figure 2-1 should be employed.

b. If the thermocouple is completely floating, the circuit shown in Figure 2-2 will be most advantageous.

c. If the thermocouple is routed to an external reference junction, the circuit shown in Figure 2-3 must be used.

2.3.2 Wiring: Multipoint T/C Selector

As explained in Section 1, the multipoint selector is a switching unit having the capability of accepting the outputs of several thermocouples; selecting one or more of them and feeding the signals into the DS350-T3.

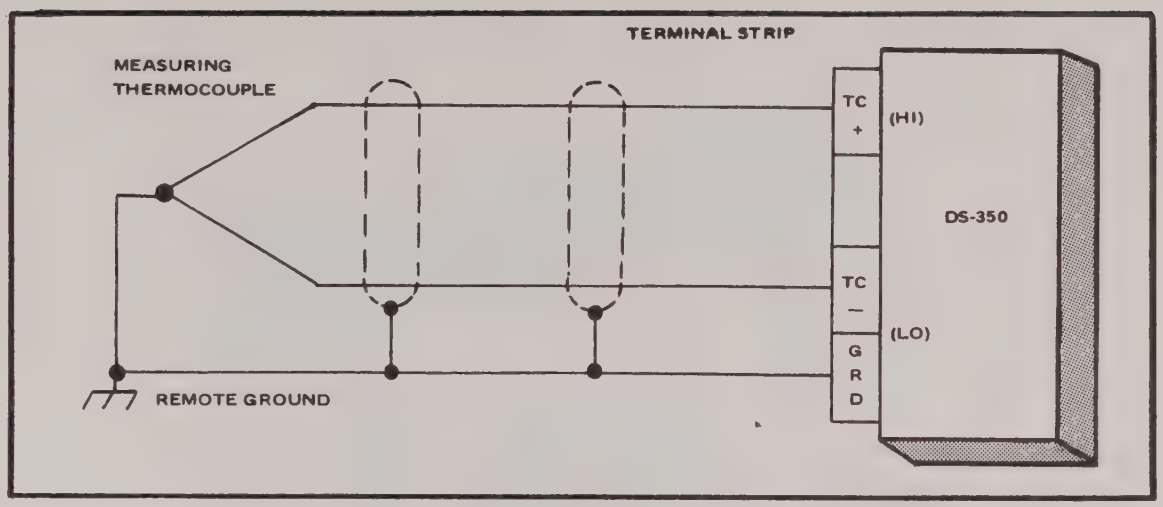


FIG. 2-1 GROUNDED THERMOCOUPLE

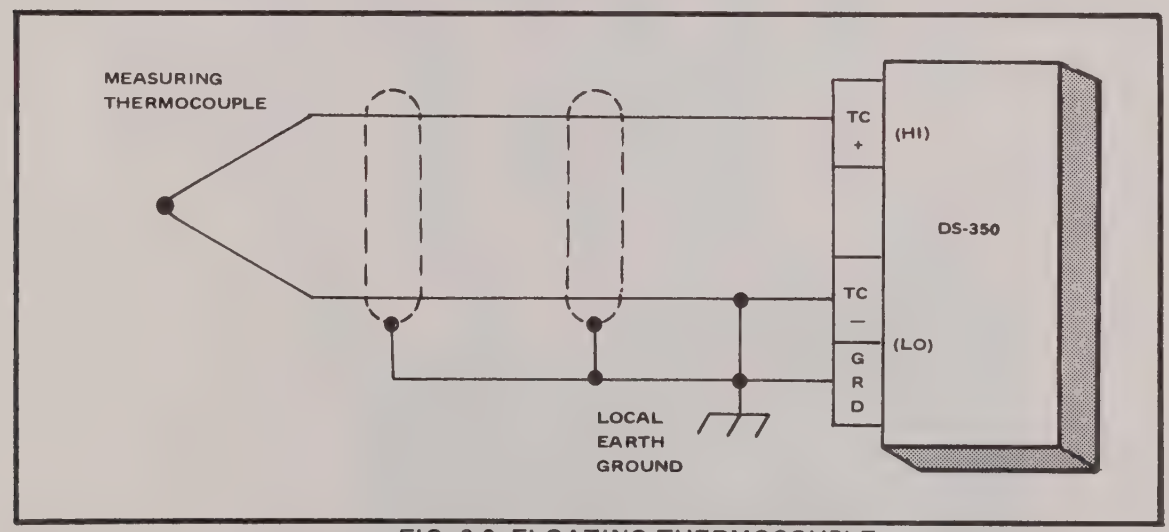


FIG. 2-2 FLOATING THERMOCOUPLE

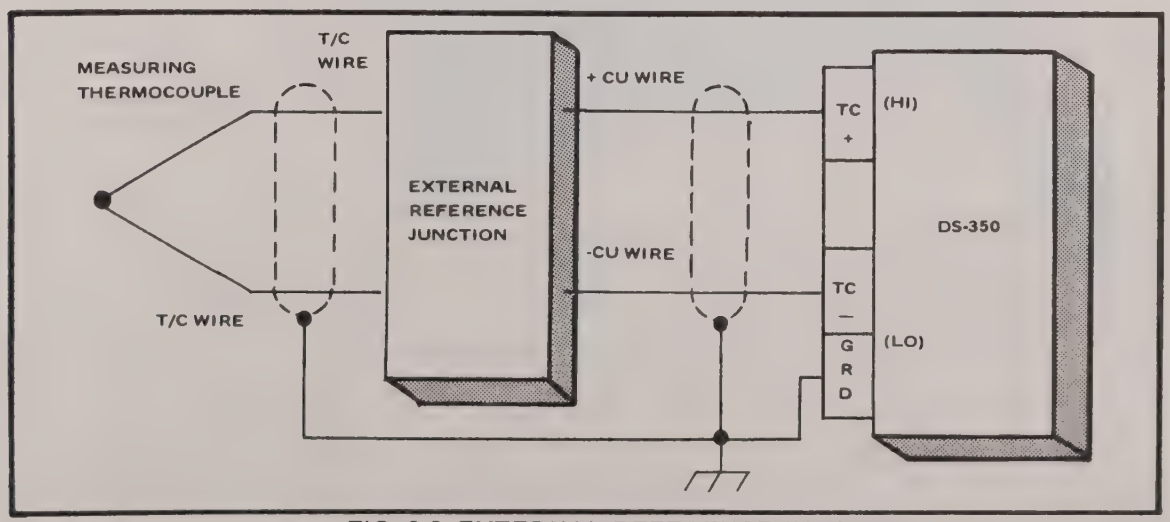


FIG. 2-3 EXTERNAL REFERENCE JUNCTION

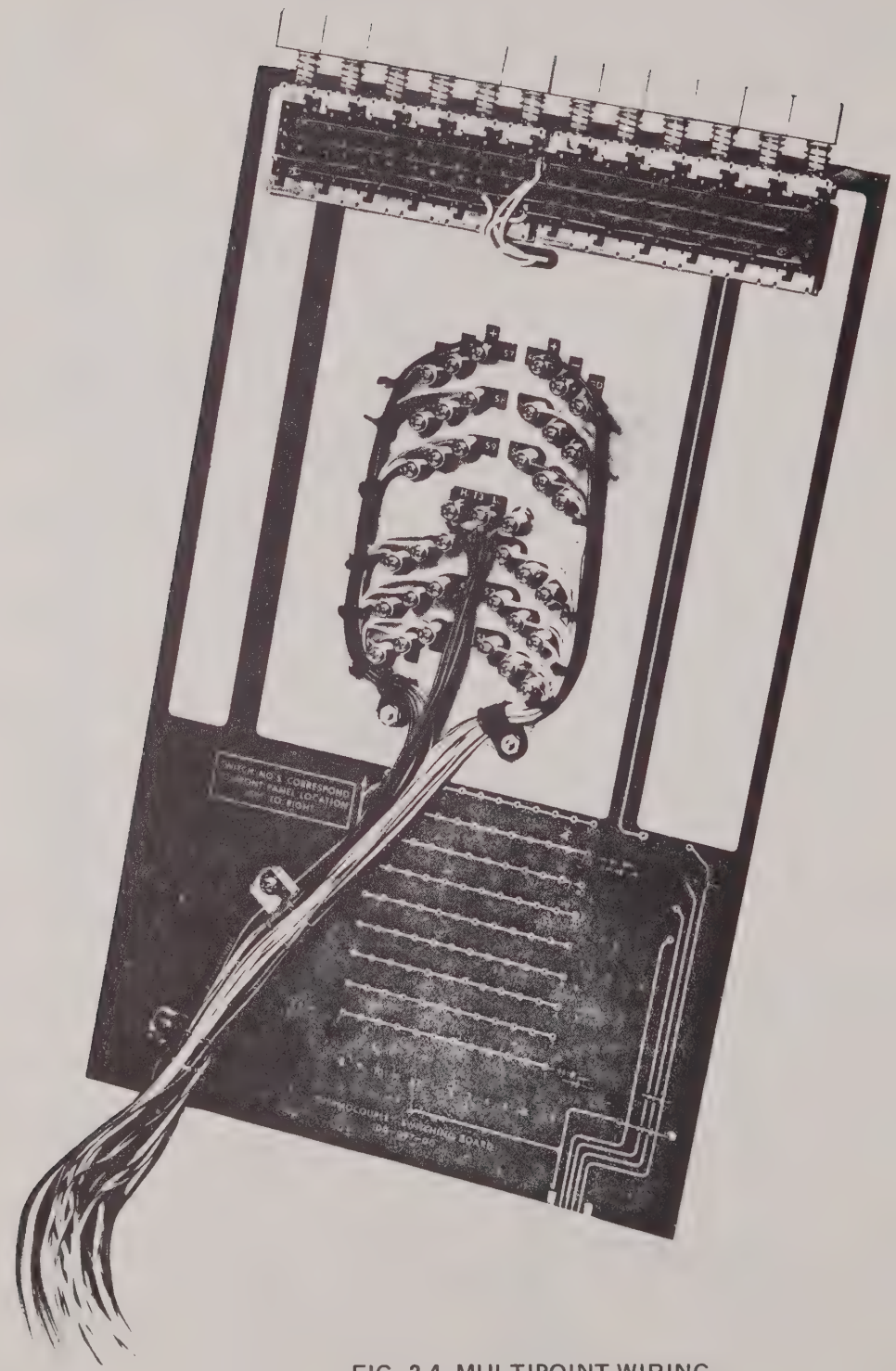


FIG. 2-4 MULTIPOINT WIRING

The front panel of the selector consists of a series of pushbutton switches (12 to a row) which select the desired thermocouple.

To wire the multipoint selector, use the applicable procedure noted below:

a. Internal 12 points

1. Remove the 2 screws securing the lower rear panel; remove the 2 screws from the bottom of the instrument and slide the circuit board out, noting how the black nylon guides are placed in the metal extrusion.
2. Using Figure 2-4 as a guide, route the thermocouple wires to the appropriate terminals. (HI = TC +; LO = TC -) Switch numbers etched on board correspond to front panel switches as viewed from left to right when facing the unit. (S1 = the first front panel switch, etc.)
3. Run thermocouple wire from the HI, LO & GUARD terminals on the board. These 3 wires attach to the respective thermocouple inputs of the DS350-T3.

b. External 12 or 24 points

1. Remove the 4 screws securing the rear panel; remove the 2 F. H. screws from the top and bottom of the instrument and slide the circuit board out, noting how the black nylon guides are placed in the metal extrusion.
2. Remove the shield by removing the 6 screws securing it to the board.
3. Using Figure 2-4 as a guide, route the thermocouple wires to the appropriate terminals. (HI = TC +; LO = TC -) Switch numbers on the bottom board correspond to front panel switches viewed left to right. (S1 - the first pushbutton on the left.) Because the second board is mounted upside down, S12 corresponds to the first switch on the left, S11 to the second, etc.
4. Run thermocouple wire from the HI, LO & GD terminals on the board. These 3 wires attach to the respective thermocouple inputs of the DS350-T3.
5. Replace the shield; slide the boards back into the housing.

2.3.3 Remote Programming/BCD Outputs

To give the instrument a remote sample command, two things must be accomplished. First, the Hold Line (Pin 20) must be tied to the +5V line (Pin 16). Then a positive-going edge of approximately 4V amplitude, 1 microsecond minimum rise time, 50 microseconds minimum duration, must be applied to Pin 21. See Figures 2-5 & 2-6.

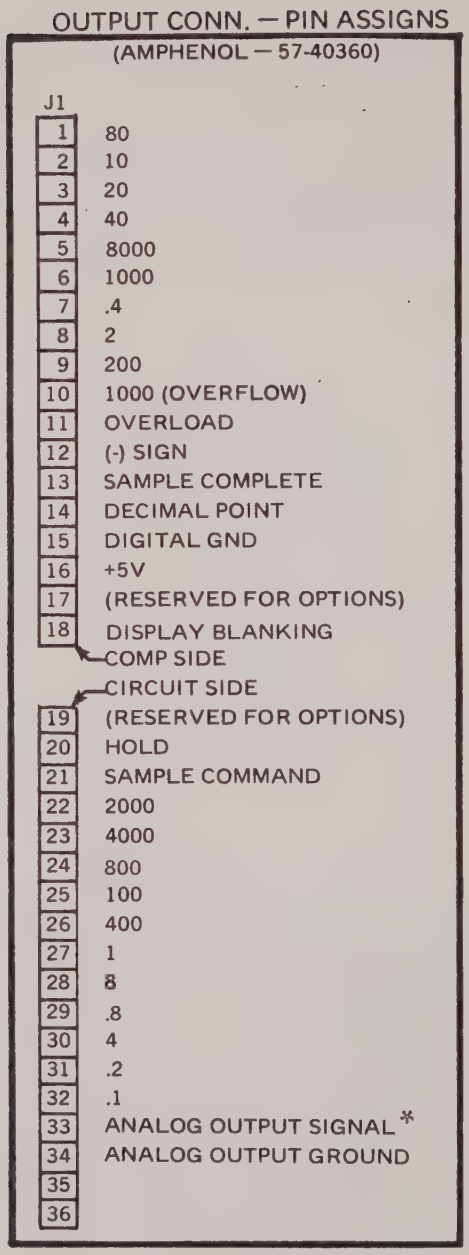


FIG. 2-5 PIN CHART I/O CONNECTOR

The BCD outputs come from a series of DTL hex inverters and have a nominal output swing of 0-5 volts. Outputs are noted in the pin chart.

Outputs are positive true logic and have a maximum output impedance of 2K.

The sample complete pulse goes to a nominal positive 5 volts at the end of an encoding, indicating that BCD numeric outputs and polarity are current and stable on J1 and ready to be read. The pulse will remain positive until the beginning of a new encoding at which time it will drop to zero. Maximum output impedance is also 2K.

2.3.4 Analog Outputs

When requested, a low impedance ($<1\Omega$) analog output is supplied by means of a connector, J1, at the rear of the instrument on pins 33 and 34. The connection should be made with a two-wire plus shield coax, with the shield connected to the guard pin and at the recorder end if the recorder is guarded. If the recorder is not guarded, the shield should be connected only at the guard pin.

Analog outputs are directly proportional to the millivolt input, being amplified to produce a full scale output of 10 volts, depending on customer requirements.

The outputs are powered by a power supply separate from internal analog supplies permitting of output ground without forming ground loops or causing deterioration in the instrument's noise rejection.

2.3.5 Using the DS-350 in a System

A typical closed loop system is shown in Figure 2-7. A print complete pulse causes the scanner to select a new channel. A sample command causes the DS-350 to accept the signal input from the new channel and an encoding begins. A sample complete pulse (print command) is taken from J1 of the DS-350 and fed to the printer where it is displayed in printed form and the entire procedure is then repeated.

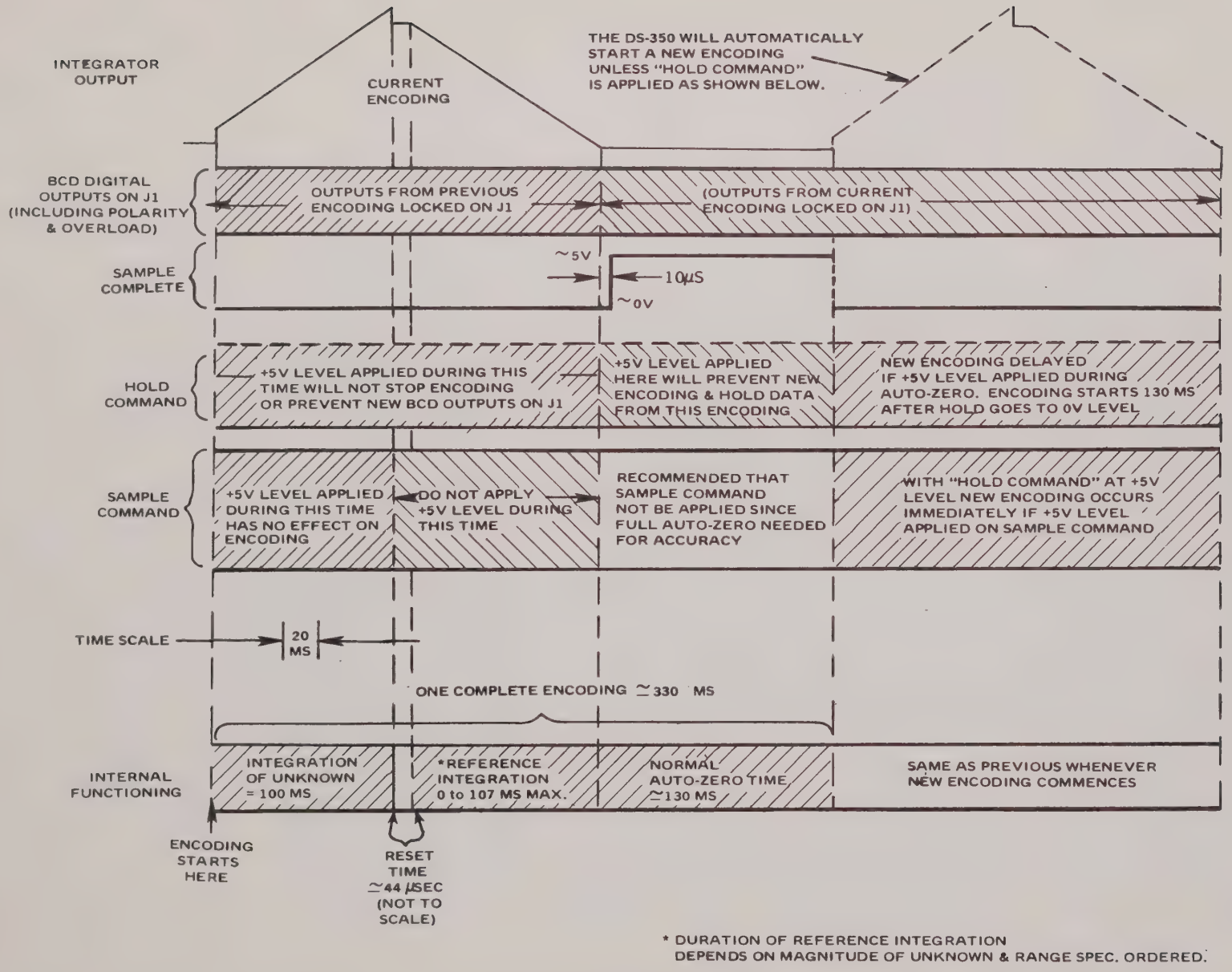

INTEGRATOR OUTPUT
CURRENT ENCODING
THE DS-350 WILL AUTOMATICALLY START A NEW ENCODING UNLESS "HOLD COMMAND" IS APPLIED AS SHOWN BELOW.
BCD DIGITAL OUTPUTS ON J1 (INCLUDING POLARITY & OVERLOAD)
OUTPUTS FROM PREVIOUS ENCODING LOCKED ON J1
(OUTPUTS FROM CURRENT ENCODING LOCKED ON J1)
SAMPLE COMPLETE
~5V
10μS
~0V
HOLD COMMAND
+5V LEVEL APPLIED DURING THIS TIME WILL NOT STOP ENCODING OR PREVENT NEW BCD OUTPUTS ON J1
+5V LEVEL APPLIED HERE WILL PREVENT NEW ENCODING & HOLD DATA FROM THIS ENCODING
NEW ENCODING DELAYED IF +5V LEVEL APPLIED DURING AUTO-ZERO. ENCODING STARTS 130 MS AFTER HOLD GOES TO 0V LEVEL
SAMPLE COMMAND
+5V LEVEL APPLIED DURING THIS TIME HAS NO EFFECT ON ENCODING
DO NOT APPLY +5V LEVEL DURING THIS TIME
RECOMMENDED THAT SAMPLE COMMAND NOT BE APPLIED SINCE FULL AUTO-ZERO NEEDED FOR ACCURACY
WITH "HOLD COMMAND" AT +5V LEVEL NEW ENCODING OCCURS IMMEDIATELY IF +5V LEVEL APPLIED ON SAMPLE COMMAND
TIME SCALE
20 MS
ONE COMPLETE ENCODING ≃330 MS
INTERNAL FUNCTIONING
INTEGRATION OF UNKNOWN = 100 MS
*REFERENCE INTEGRATION 0 to 107 MS MAX.
NORMAL AUTO-ZERO TIME ≃130 MS
SAME AS PREVIOUS WHENEVER NEW ENCODING COMMENCES
ENCODING STARTS HERE
RESET TIME ≃44 μSEC (NOT TO SCALE)
* DURATION OF REFERENCE INTEGRATION DEPENDS ON MAGNITUDE OF UNKNOWN & RANGE SPEC. ORDERED.

FIG. 2.6 I/O TIMING DIAGRAM — DS-350

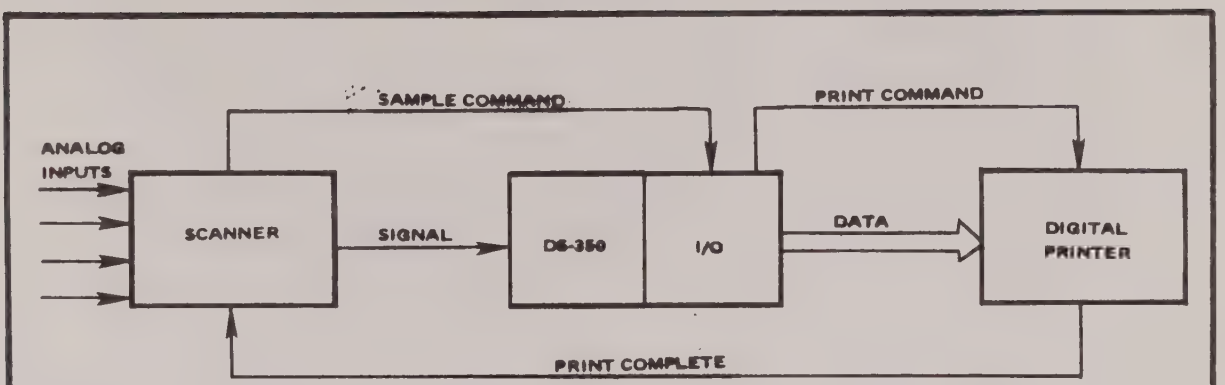


FIG. 2-7 TYPICAL SYSTEM INTERFACE

One problem exists when the DS-350 is used in a scanning application. During the initial encoding of a channel's analog signal, the DS-350's input filter is settling. This unavoidably introduces an error in the output. (If two or more readings are to be taken from a channel prior to switching, the second and subsequent readings will be correct as the input filters will have settled. However, when the scanner switches channels, the first encoding of the new input will again be in error.)

To eliminate this error, an external time delay must be introduced. This is accomplished by breaking the remote encode line and wiring in delay of 570 MS for .1% accuracy and 770 MS for .01% accuracy. (Figure 2-8).

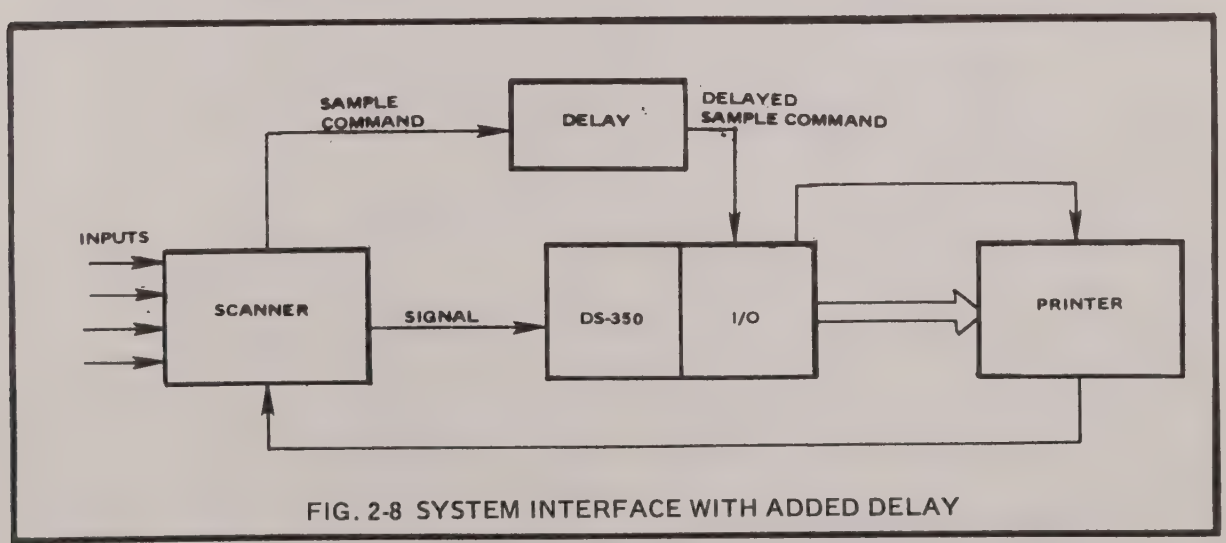


FIG. 2-8 SYSTEM INTERFACE WITH ADDED DELAY

2.4 DS-350-T3 TEMPERATURE TRANSFER STANDARD OPTION

2.4.1 Description

This option converts the highly accurate DS-350 into a temperature transfer standard capable of calibrating other temperature indicators in the laboratory or field. The tedious use of NBS thermocouple tables has been completely eliminated since the DS-350 has the appropriate table stored electronically in an internal memory and automatically applies required corrections.

Whenever the transfer standard option is incorporated, the following changes to the DS-350 occur:

a. The power switch is removed. The instrument becomes fully operational by plugging in the power cord.

b. Two pots are mounted on the front panel, one for coarse adjustment and the other for fine adjustment. In addition, a pushbutton switch is also located on the front panel. When this pushbutton switch is "IN," the instrument is in the Transfer Standard mode. When the pushbutton is in the "OUT" position, the instrument becomes the standard DS-350 fully described in the manual. All hook-up, operating and calibration procedures noted in the manual apply to the unit when it is in this mode.

2.4.2 Operation

If use as a thermocouple indicator is desired, move the front panel pushbutton to the "OUT" position and refer to the attached manual for all phases of operation, calibration, etc.

If use as a transfer standard is desired, perform the following procedure:

a. Turn on the instrument and allow a full 30-minute warmup.

b. Depress the front panel pushbutton to place the instrument in the Transfer Standard mode.

c. Interface the DS-350 to the instrument to be calibrated, following the wiring diagram as shown:

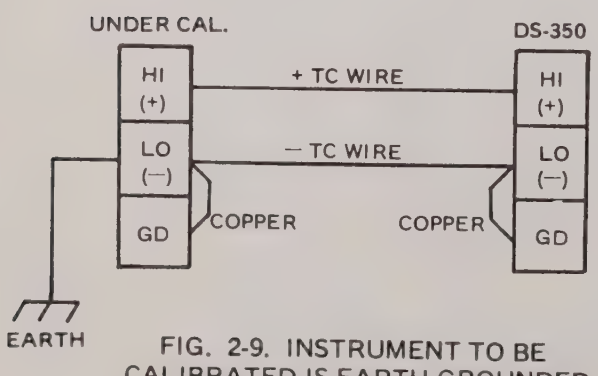


FIG. 2-9. INSTRUMENT TO BE CALIBRATED IS EARTH GROUNDED

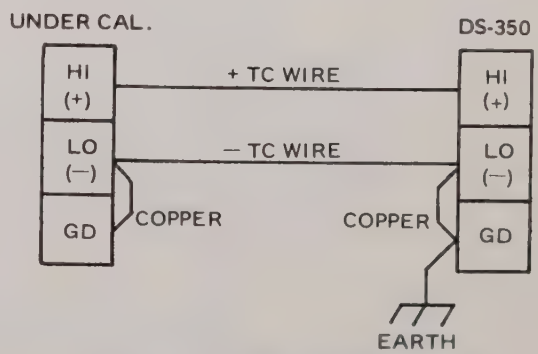


FIG. 2-10. INSTRUMENT TO BE CALIBRATED IS FLOATING

NOTES

1. Not all instruments to be calibrated will have a guard terminal. The guard-to-lo connection on the DS-350 should always be made. Keep TC wire reasonably short and free of service loops.
2. The instrument to be calibrated must be of the same thermocouple type as noted on the front panel of the DS-350.
3. Interconnections between the DS-350 and the unit to be calibrated must be made with thermocouple wire.

d. Adjust the coarse and fine pots on the DS-350 front panel until the DS-350 displays the desired reading. (Any display between the limits engraved on the front panel is possible.)

e. Make the appropriate adjustments to the instrument being calibrated until its display agrees with the display on the DS-350.

2.4.2.1 Recommended Calibration Procedure for Manual Null-Balance Pyrometers Such as Thermo Electric Model 80237 "Minimite"

a. Hook up correct type wire between corresponding terminals on DS-350 and pyrometer. Cover reference junction compensating terminals on both instruments with clean cloths. Turn on DS-350. Push front panel pushbutton to "calibrate" and allow at least 10 minutes for stability.

b. Standardize pyrometer against its internal standard cell by holding FUNCTION SELECT switch to "STD" position and turning "STD ADJ" knob for null on panel meter.

c. Using COARSE and FINE adjustment knobs on DS-350, set a desired temperature calibration point on DS-350's readout. Record this temperature in "actual temperature" column on data sheet.

d. Set temperature dial on pyrometer to reading on DS-350. Check that pyrometer range select knob is in correct position.

e. Depress and hold "TEST" button on pyrometer and turn pyrometer temperature dial until reading on DS-350 is restored to original setting.

f. Release pyrometer "TEST" button and record temperature on pyrometer dial in "indicated temperature" column on data sheet.

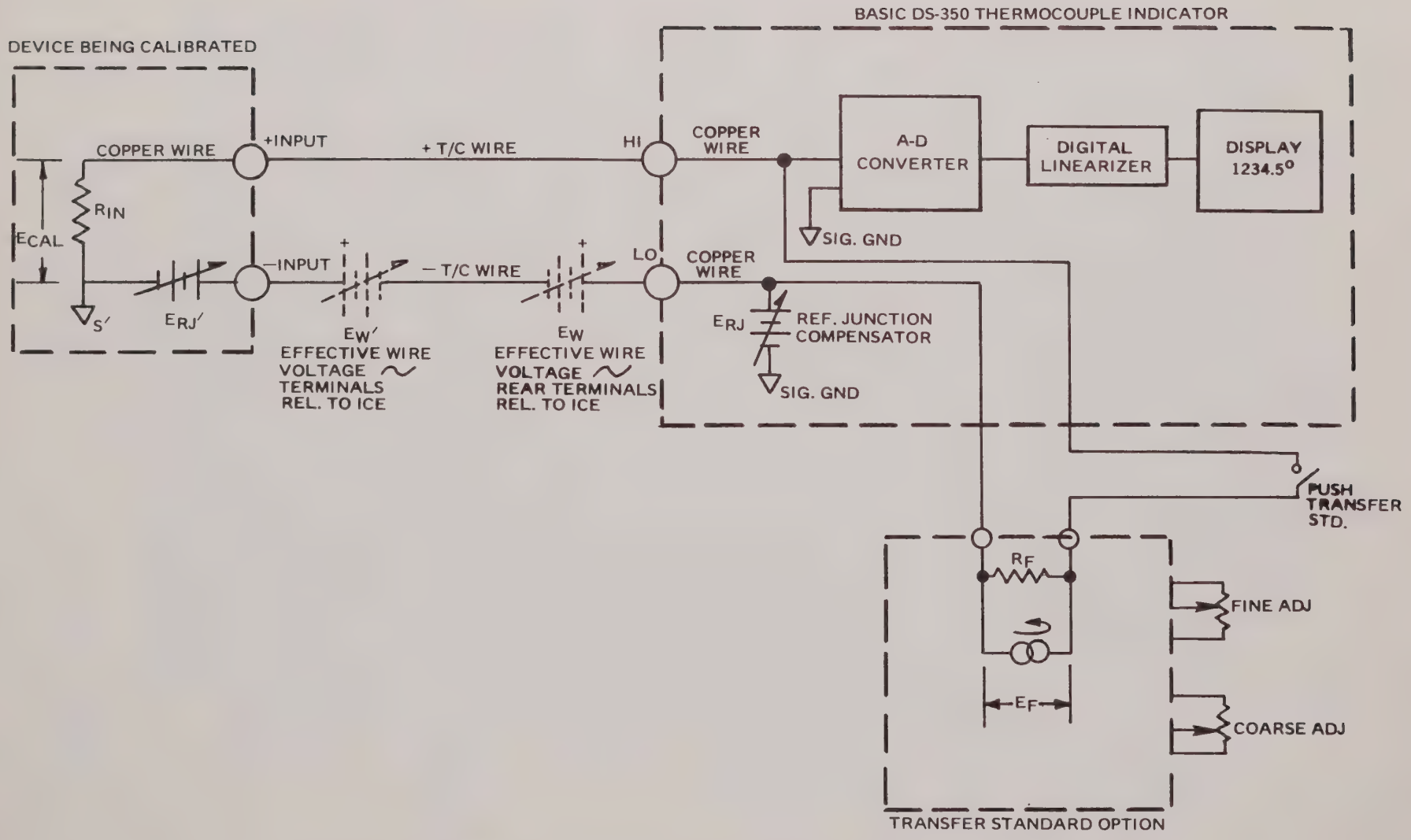


FIG. 2-11 BLOCK DIAGRAM TEMPERATURE TRANSFER STD.

g. Repeat Steps b through f inclusive for all desired calibration points.

h. Adjust pyrometer as per manufacturer's instructions for best match between "actual" and "indicated" temperatures.

2.4.3 Theory

(Refer to Figure 1.) The option consists of a floating, stable reference voltage, E_F, which can be applied between the DS-350's HI and LO terminals by a front panel selection switch. The voltage is adjustable across the entire required range by front panel coarse and fine potentiometers, and since it is applied at the same terminals as the thermocouple wire, the A-D converter cannot distinguish between voltage generated by thermocouple wire and the floating E_F source.

Thermocouple wire is used to connect the DS-350 to the indicator or recorder being calibrated. The device under calibration can be characterized by its input impedance, R_{IN} and its own reference junction compensation voltage, $E_{R'J}$.

The thermocouple wire's net voltage contribution can be represented by the difference of two voltage generators E_W and $E_{W'}$.

I. $E_{WIRE\ TOTAL} = E_W - E_{W'}$

By design, each reference junction compensator cancels the effect of its local thermocouple wire generator referenced to ice. Thus,

II. $E_{R'J} = E_{W'}$

III, and $E_{RJ} = E_W$

} At all temperatures over the compensation range.

Since, $E_{R'J} = E_{W'}$ these two generators may be removed from the circuit.

Now, the DS-350 A-D sees the sum of E_{RJ} and E_F, thus,

IV. $E_{A\text{-}D} = E_{RJ} + E_F$

But, the device under calibration sees the sum of E_W and E_{CAL}

V. $E_{CAL} = E_W + E_F$

However, substituting III. in V., we get

VI. $E_{CAL} = E_{RJ} + E_F$

But IV and VI are equal; therefore,

$E_{CAL} = E_{A\text{-}D}$ (A desired result.)

This shows that the device under calibration receives the same voltage as the DS-350 A-D converter, and that compensation has occurred for temperature changes of the thermocouple wire junctions.

Since E_{A-D} is digitized and displayed through the main unit's digital linearizer, and NBS tabular relationship exists between E_{A-D} and the temperature displayed in the readout.

Stability of the temperature display is limited by stability of E_{RJ} since $E_{A-D} = E_{RJ} + E_F$ and by design E_F is made very stable. On the other hand, E_{RJ} must change as the temperature of the DS-350 HIGH and LOW terminals change in order to compensate for thermoelectric effects (E_W). Thus, depending on the rate of ambient temperature change, it will be necessary from time-to-time to restore a desired calibration temperature in the display by turning the FINE adjust control.

2.4.4 Temperature Transfer Standard Option Specifications

CALIBRATION METHOD: Automatic transfer calibration from highly stable DS-350 digital thermometer to other temperature indicating/recording instruments. No tedious null-balance techniques required. No NBS table look-up required due to drift-free digital linearization by internal read-only memory (ROM) programmed to applicable NBS table.

WIRE TYPES & RANGES: Same as types and ranges for basic DS-350 thermometer. Specials on request at extra cost.

OUTPUT CIRCUIT & HOOK-UP: Same terminals as input. Thermocouple wire connects DS-350 with device being calibrated. Option allows device under calibration to be grounded or floating and digital outputs to be grounded or floating with no CMR degradations to basic instrument. Up to #14 AWG thermocouple wire accommodated.

RESOLUTION: 0.1 degree except on certain ranges as listed.

STABILITY: Stability of reading better than .2 deg/minute, but stability of actual calibration voltage versus reading is the same as basic DS-350.

SOURCE TEMPERATURE: (i.e., the input impedance of device being calibrated). Infinite down to 1K ohm for guaranteed full range for range specification ordered. No degradation of accuracy for impedances less than 1 K ohm, but +F.S. of range specification may not be achieved.

COLD JUNCTION COMPENSATION: Automatic. No error at calibration ambient of 77° ± 2° F; temperature effects of ± .025° F/° F from 50 to 104° F, around midpoint, regardless of TC type.

BREAK DETECTION: Automatically disabled in transfer standard mode; fully active in normal operation mode.

OUTPUT CURRENT: Short circuit limited to 290 microamperes.

section 3

theory of operation

3.1 INTRODUCTION

The DS-350-T3 thermocouple thermometer accepts thermocouple outputs in the form of low level DC voltages and measures them by using a dual slope integration method which is enhanced by Doric's AUTO-ZERO (Patent Pending).

During encoding of a voltage signal, the analog input of the meter is connected to the DC signal voltage for 100 ms (see Figure 3-1). During this fixed time (t_1), the integrating capacitor, C22, charges at a rate proportional to the DC signal voltage (E_x). At the end of this fixed integration time, the input of the DS-350-T3 is automatically disconnected from the signal source and connected to signal ground. Simultaneously, a precision reference voltage of the same polarity is connected to the integrator's "summing" node. This causes the integrating capacitor to discharge towards ground at a fixed rate. The discharge time (t_2)

required to reach ground is proportional both to the reference voltage and to the voltage peak (E_p) reached by the capacitor during the fixed integration time (t_1).

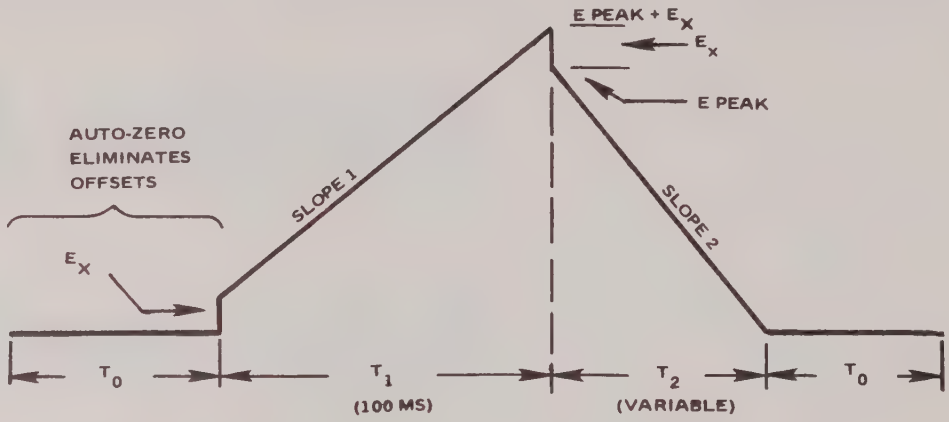


FIG. 3-1 DUAL SLOPE TECHNIQUE

Figure 3-1 shows that t_2 time is directly proportional to E_x and independent of variable factors such as the RC constant, clock frequency, amplifier gains and offsets.

To display E_x digitally, a constant kHz is fed into the display counter during t_1 time. During t_2 time, a series of selected, varying frequencies is fed to the counter for a time proportional to the thermocouple voltage. Because of the varying frequencies, the counts are accumulated non-linearly, thus compensating for the non-linearity of the thermocouple output.

For every N counts into the display counter, a count is sent to the segment counter. The segment counter causes a set of frequencies to be selected via the digital programmer. The segment counter and digital programmer cause the frequency generator to put out a new frequency for each segment up until the time proportional E_x is reached. The number in the display counter is then displayed.

3.2 AUTO-ZERO (Patent Pending)

Between encodings, the instrument automatically disconnects itself from the signal source E_x and shorts its own input (see Figure 3-2). At this time, the AUTO-ZERO circuit measures the existing offset in the integrator amp and zero crossing amp. At the beginning of the next

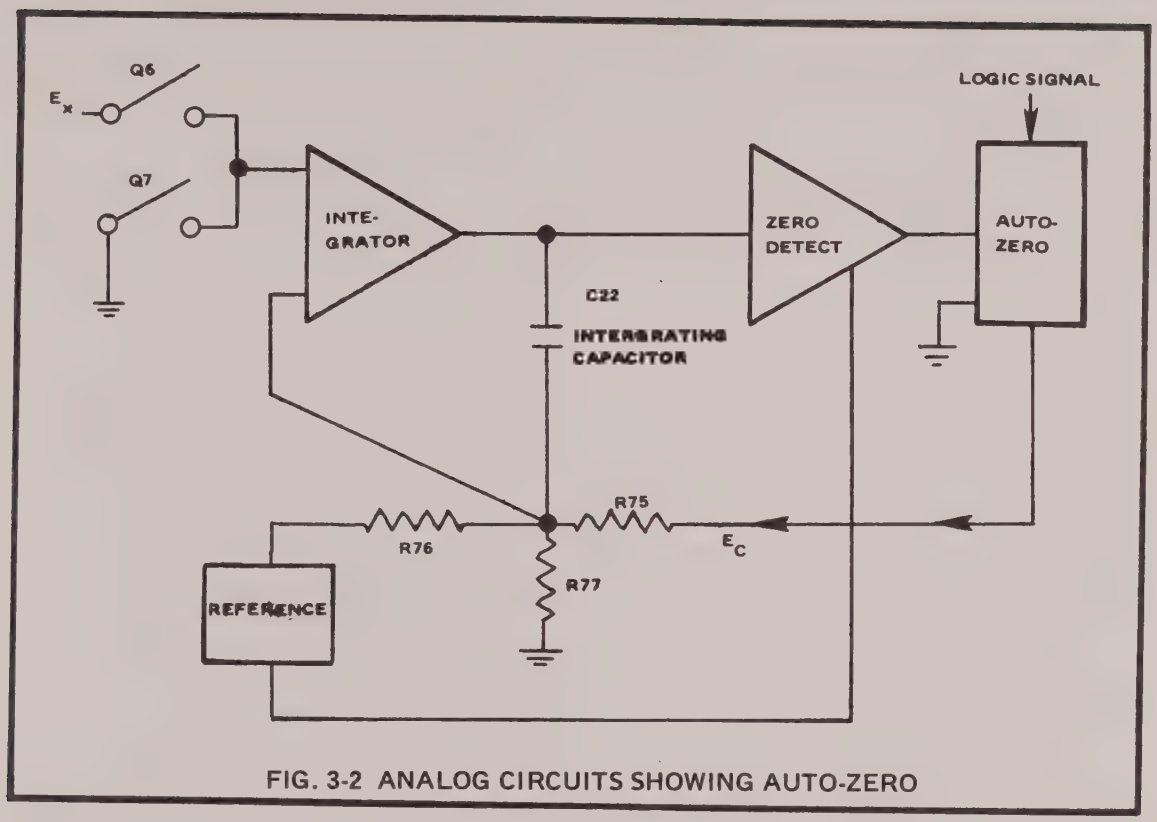


FIG. 3-2 ANALOG CIRCUITS SHOWING AUTO-ZERO

encoding, the AUTO-ZERO circuit stores the required voltage to cancel the sum of the offsets in these amplifiers.

Between encodings, the integrator's amp's input is connected to ground. Note that the integrator and zero crossing amps are in series. Any offsets occurring in the integrator are amplified in the zero crossing amp and fed to the AUTO-ZERO. The amplified sum of all these offsets and slow drifts (E_s) is compared with reference to ground by the AUTO-ZERO which feeds back a correction voltage (E_c) to the integrator amp to force E_s to equal zero volts. As long as the operation continues, the output cannot drift off of zero.

3.3 MEASUREMENT CYCLE

When the measurement cycle starts, Q7 opens and Q6 closes, applying E_x to the integrator, Z4 (see Figure 3-2).

At the time that Q6 closes, a counter starts to count up from zero to 800 to provide the fixed time base, t_1. When the 800 is reached, Q6 is opened and either Q22 or Q23 is closed to either $+E_r$ or $-E_r$ as required to make the output of Z4 slew towards ground. As Q22 or Q23 closes, the counter is reset to zero and again counts up from zero. When the charge on C22 is reduced to zero volts, the counting is stopped and the number accumulated in the counter is displayed on the readout.

3.4 CIRCUIT DESCRIPTION

3.4.1 Reference Junction

The reference junction used in the DS-350-T3 is a Doric proprietary cold junction compensator providing the equivalent of an ice bath temperature of 32° F. It contains a self-compensating voltage generator network as shown in Figure 3-3. As the ambient temperature surrounding TC2 and TC3 varies, a thermally generated voltage appears and produces an error in the output. However, an equal voltage of the opposite polarity is automatically introduced by the series generator, cancelling out the thermal error and maintaining the correct TC1 output over a wide ambient temperature range.

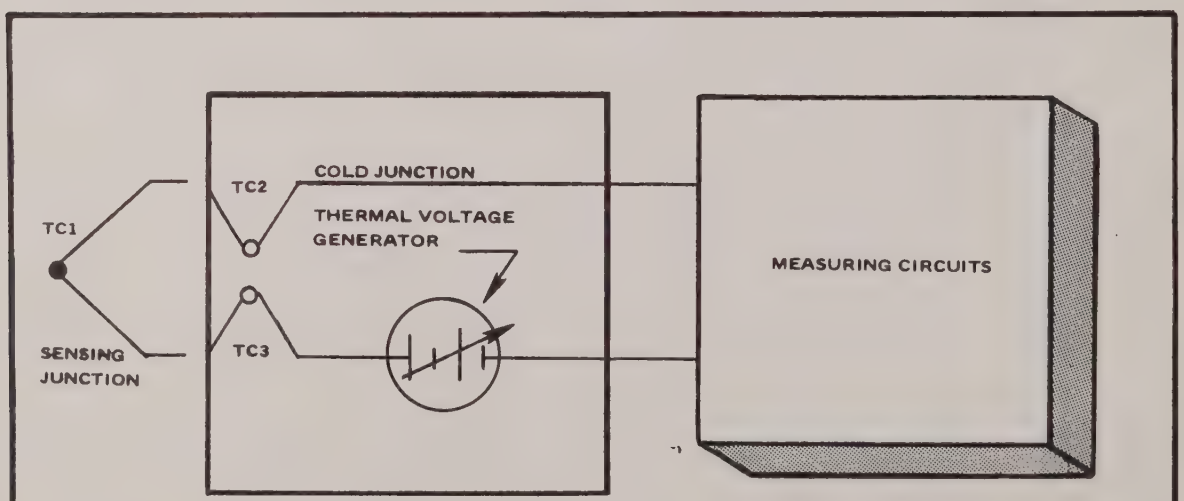


FIG. 3-3 REFERENCE JUNCTION

The reference junction provides the interface between the thermocouple wires and the instrument's inputs without the introduction of any secondary thermocouple errors.

Power to the reference junction is derived from the CR22 Reference Zener Diode and -15 volt supply.

3.4.2 Zero Adjustment

A precision resistor within the reference junction assembly and in series with the LO lead provides the means for junction compensation and zero offsets when required by some range specifications.

The offset pot, R3, provides a means for adjustment of scale zero or offset & should be used only during calibration. (See Section 4.)

3.4.3 Input Filter & Limiter

The filter/limiter circuitry consists of a three-pole passive notch filter with an overload protection limiter attached within the filter. This limiter (DS1) prevents high voltage from damaging the input stage by limiting the input to ±50 volts.

3.4.4 Analog Switching

There are five analog switching channels in the DS-350, all essentially the same. Each channel is formed by a high-level driver and junction FET switch. The drivers convert I. C. logic levels to high voltage swings; then the FET switches convert these voltage swings to solid-state "closures." When the driver is turned off, the FET gate becomes zero biased with respect to the source causing a low impedance to appear between drain and source. When the driver is turned on, the gate is pulled negative which causes several thousand megohms to appear between drain and source.

3.4.5 Sample Rate Generator

The sample rate generator is an RC timing latch that commands the L_1 flip-flop to start each new encoding. The SRG is controlled by L_0: As L_0 goes low at the end of an encoding Q3 is turned off and C13 begins to charge positively at a rate of approx. 7V/sec. This ramp is coupled with the clock sync (by C11) and fed to the emitter of Q4. The base of Q4 is biased by Z31(9) at +2.5v. As the emitter of Q22 approaches +3 volts, a positive going clock pulse will trigger Q4 on, causing Q5 to turn on, clamping the input of Z31(9) to GND. The inverted state of Z31 will set L_1 positive and start a new encoding. The positive level of L_1 will set L_0 positive which, in turn, turns Q3 on, discharging C13, resetting the latch formed by Q4 & Q5.

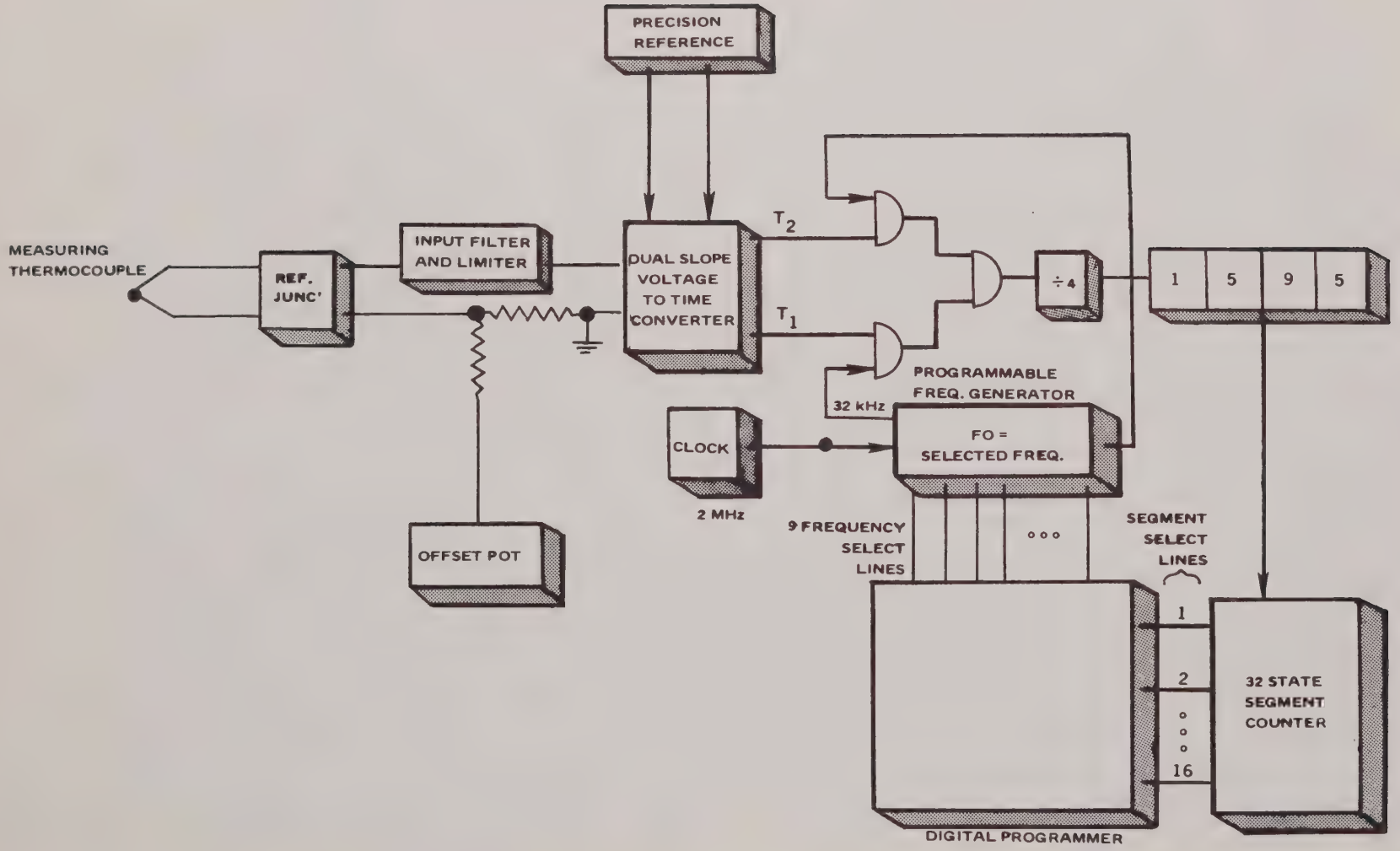


FIG. 3-4 BLOCK DIAGRAM

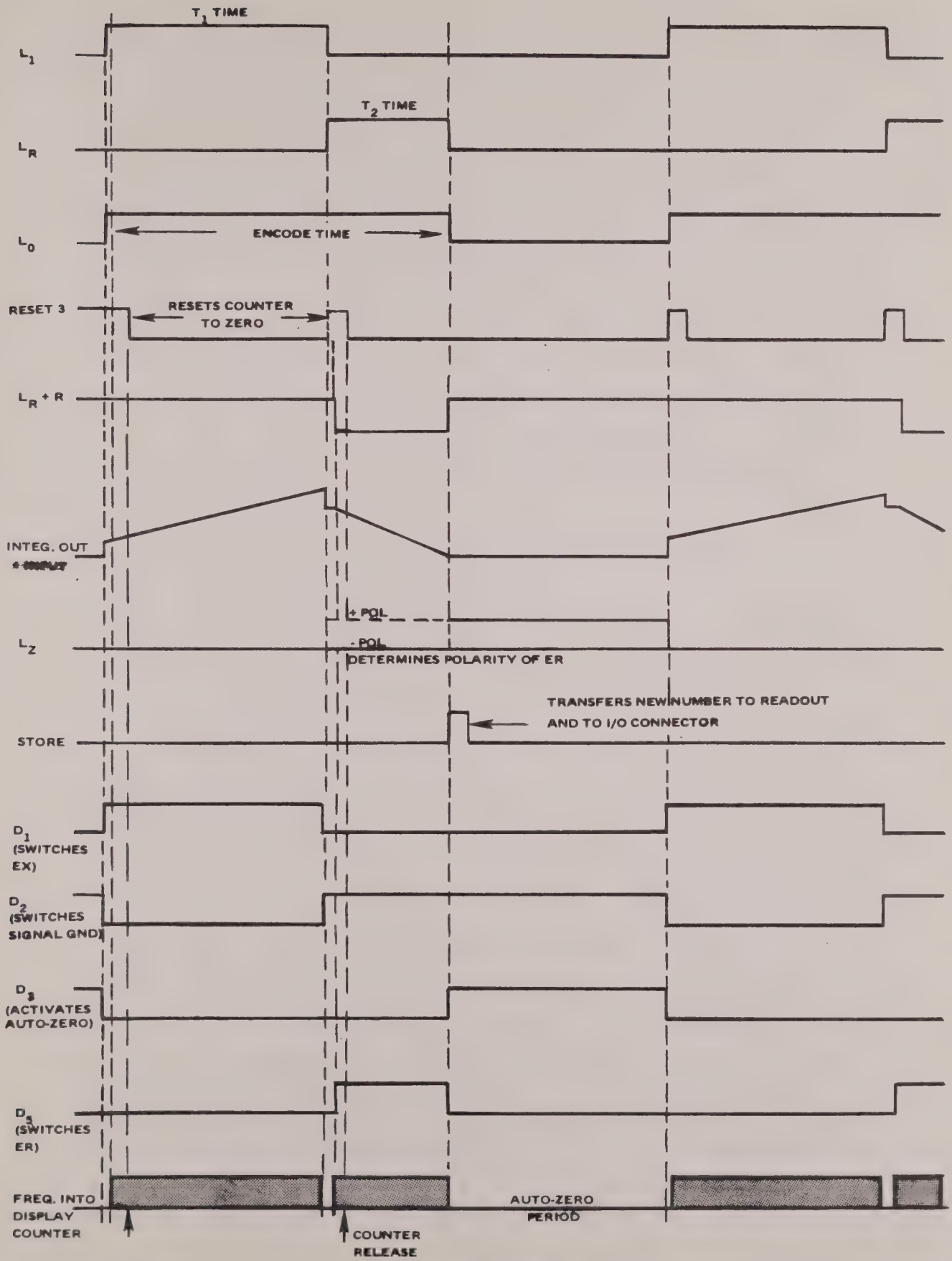


FIG. 3-5 DS-350 TIMING DIAGRAM

3.4.6 Integrating Amplifier

The integrating amplifier is a high-input impedance, high gain operational amplifier. Its first stage is a dual FET amplifier which has a very high input impedance and very low current offset. The amplifier has a typical gain of 10. Its output drives the input of an operational amplifier with a typical open loop gain of 80,000. Capacitor C22 supplies negative feedback to the summing junction and R76 and R77 determine system scaling.

3.4.7 Zero Crossing Amplifier

The zero crossing amplifier is a two-stage, wideband DC amplifier which detects the zero crossings of the integrator amplifier. R64 is a current limiter which prevents overload to the integrating amplifier or damage to Q18. Typical open loop gain is 50.000.

3.4.8 Zero Crossing Detector/Dual Differentiator

The zero crossing detector squares up the amplified zero crossing to provide a logic level transition at the exact moment the integrator crosses zero. Q18 & Q19 form the detector and feed a logical high level (for positive input signals) or low (negative) to inverter Z31(11). The dual differentiator provides a brief "unipolar" reset pulse to reset flip-flop L_R whenever the zero crossing detector registers a change of polarity from either direction.

3.4.9 Auto-Zero Circuit

The auto-zero circuit consists of a sample and hold circuit. R69 and R70 translate the zero crossing amplifier output voltage to the input of Q20. Q20 couples this voltage to the storage capacitor, C28. Q21 is a high input impedance source follower which supplies the correction voltage E_c to the integrator. When an encoding starts, Q20 is turned off, and the last voltage required to zero the system is stored on C28, assuring a continuous correction voltage is applied to the input integrator throughout the encoding. See Fig. 3-2.

3.4.10 Reset Generator

The reset generator is a monostable multivibrator formed by a dynamic NOR gate followed by two flip-flops. The positive going edge of either L_1 or L_R logic levels cause a brief low level to appear at Z21(10); this transition resets Z13(5) which, in turn, resets Z13(3). 31 μsec, later the negative edge of the 32 kHz signal on Z13(9), will clock Z13(5) to its positive state removing the reset on Z13(13), and will clock Z13(6) to its low state, turning Q27 off. C48 will begin to charge positive pulling Z13(1) toward a high logic level. Some μsec later (94 μsec at beginning of L_1 period and 12 μsec at beginning of L_R period) the concurrence of Z13(1) at a high level and a

negative going edge arriving on Z13(12), clocks Z13(3) high and Z13(2) low, ending the reset cycle.

3.4.11 Clock

The clock is a tuned-collector oscillator. L_1 and C41 in the collector of Q24 establish the nominal frequency of 2.050 mHz and the emitter follower Q25 makes oscillation possible by both providing a power gain greater than one and feeding back a signal in phase with the collector of Q24. The inverter Z31 provides buffering for the clock loads.

3.4.12 Programmable Frequency Generator

In order to linearize a non-linear thermocouple output, some part of the A to D converter must be made non-linear, but in a highly precise and reproducible way. To accomplish this, two things are needed: a programmable frequency generator and a digital programmer to control the generator.

The frequency generator employed in the DS-350 consists of two binary rate multipliers, Z32 and Z37, working together. The input frequency for the generator is from the clock. This frequency is, in turn, divided down by a string of flip-flops internal to Z32 & Z37. Thus, a series of nine octavely related frequencies is developed which can be summed together in any combination under the control of Z38, the programmer.

The summed frequencies from both Z37 & Z32 appear on Pin 6 of Z32 and are fed into the A-D converter during the t_2 period thru Z22 (the frequency select), Z23 & Z29 (the smoother) and Z32(1, 2) (the counter gate).

3.4.13 Digital Programmer

The programmable frequency generator is under the control of the digital programmer, enabling the programmer to periodically change the frequency going to the A to D converter during the t_2 period. The varying rate at which the counter section of the A to D accumulates counts accomplishes the desired linearization of the display.

The heart of the digital programmer (Z38) is a programmable read-only memory, programmed by Doric during production. The memory can hold a maximum of 32, 8-bit binary words. The logical true and false levels of a given binary word directly drive the "rate" inputs to the frequency generator. Although the memory can store only 8 bits per word, the frequency generator is driven by 9 rate inputs — the additional bit is furnished by a "9th bit generator,"

(Z35 and Z40), a Doric innovation which samples selected output word bits & addresses and synthetically generates a desired extra bit by fixed rules of logic.

The read-only memory is addressed by the preset segment counter (Z29 (3, 12), Z33, Z34 & Z30) which counts segment "marking" pulses coming from the segment generator (Z3) which, in turn, is sampling the display counter.

3.4.14 Display Counter

Dependent upon full-scale requirements, the display counter consists of four or five identical decades. Each decade is made up of an 8-4-2-1 BCD counter, a gated latch storage unit and a BCD to decimal decoder-driver. The counter accepts pulses from Z31(2) and divides the frequency by 10. Output from the 8-bit is fed to the next decade. All four bits of each decade are fed to the storage unit. At the end of an encoding, the four bits in the counter are transferred into the flip-flops of the storage unit by a brief "store" pulse coming from the collector of Q26. At all other times, the storage unit ignores any changes in the state of the counter. Outputs of the storage unit are connected to the decoder-driver inputs. The decoder-driver contains internal logic which converts the binary information into one-out-of-ten information. Output is in the form of 10 high voltage driver lines which are connected to the ten cathodes of a nixie tube.

3.4.15 Polarity Detection

Information for polarity determination is available on the L_Z and $\overline{L_Z}$ lines at the beginning of L_R. This information is provided to the polarity flip-flop Z36. During the reset period preceding the start of t_2 time, the negative going edge of $\overline{L_R}$ + R causes the polarity information to be set into Z36. If Z36, Pin 2, is high, the minus sign will be turned on. A positive polarity is not displayed.

3.4.16 Overflow One

The principle of operation for the "overflow one" storage flip-flop (Z27) is similar to that of polarity detection. Carry information is supplied to Z41(9) from the counter during t_2 time by the trailing edge of an 8-bit counting pulse. This clocks Z41(5) to a logical true level. The trailing edge of the store pulse arriving at Z41(12) causes the information to be transferred from Z41(5, 6) to the Z41(1, 4) flip-flop. High voltage driver Q28 displays the information through the "1" neon.

3.4.17 Overload Detection

The overload detection circuitry consists of four gates from Z30 and transistors Q30 and Q31. Pins 10 and 13 of Z30 form an R-S flip-flop which controls the on-off of Q31. Z30 (1, 2, 3) acts as an inverter. Pins 2 and 3 of Z30 are connected (by a selection feedthrough) to either Z18 or Z25 decade counter for a desired overload count. L_1 inhibits Z30(4) output during t_1 time. During t_2 time, L_1 is low, while the selected decade count line will remain low until the selected overload count is reached. When this occurs, the decade count line will go high, causing Z30(4) to set the flip-flop. Thus, Z30, Pin 13, goes low turning Q31 and Q30 off, releasing the VCC power supply connection for the nixie decoders. The nixies will then blur until the start of the next encoding, indicating an overload condition. When the next encoding begins, the reset pulse will reset the flip-flop turning Q31 back on. This sequence will repeat itself so long as an overload condition exists.

3.4.18 High Speed Break Detection

Q1, Q2, Q37 and associated components form an active, coherent continuity tester for the input thermocouple. The Monostable Multivibrator (65, R149, R150, R163, Q37) generates a continuity test pulse of about 7 volt amplitude and 140 microseconds duration at the beginning of each encoding. This pulse is differentiated by C1 and associated line impedances and applied to both the thermocouple and input filter. Because of the differentiating action, the injected positive test pulse is immediately followed by a canceling negative pulse which prevents the filter output from slewing.

Q1 and Q2 form a regenerative detector-driver which is enabled by Q37 only at the moment of test. If the thermocouple is broken or line impedance substantially exceeds 1.5K, Q2 comes on, charging up the rear of the input filter (C7) and overloading the input.

3.4.19 Development of T1 Period

As shown in Fig. 3-1, the integration of the unknown input voltage last for 100 milliseconds — this period is developed digitally.

One of the octavely-related frequencies from the frequency generator (see 3.4.12) is always present at Pin Z37-7, irrespective of generator programming. This 32 KHz component is selected by the frequency select during the auto-zero period and T1 period and divided by four, appearing as an 8 KHz signal on Z23(5).

The 8000 Hz signal is switched into the counter during T1 and when 800 counts have been accumulated, Pin Z14-11 sends a pulse to Z28-8 through C14, ending the T1 period.

section 4

calibration & maintenance

4.1 TEST EQUIPMENT NEEDED

A DC calibrator capable of supplying accurate voltages up to 100 mv with better than 1 microvolt resolution and stability is required. A stable agitated ice bath, accurate to .05° is also needed.

4.2 CALIBRATION PROCEDURE

(For Instruments Having Internal Reference Junction)

a. Prepare test wires as shown in Figure 4-3.

b. Hook the DC calibrator and ice bath to the DS-350 as shown in Figure 4-1.

c. Turn on the calibrator, DS-350 and bath agitator and allow entire setup a 30-minute settling time.

d. Refer to Figure 4-4 and follow the calibration instructions noted.

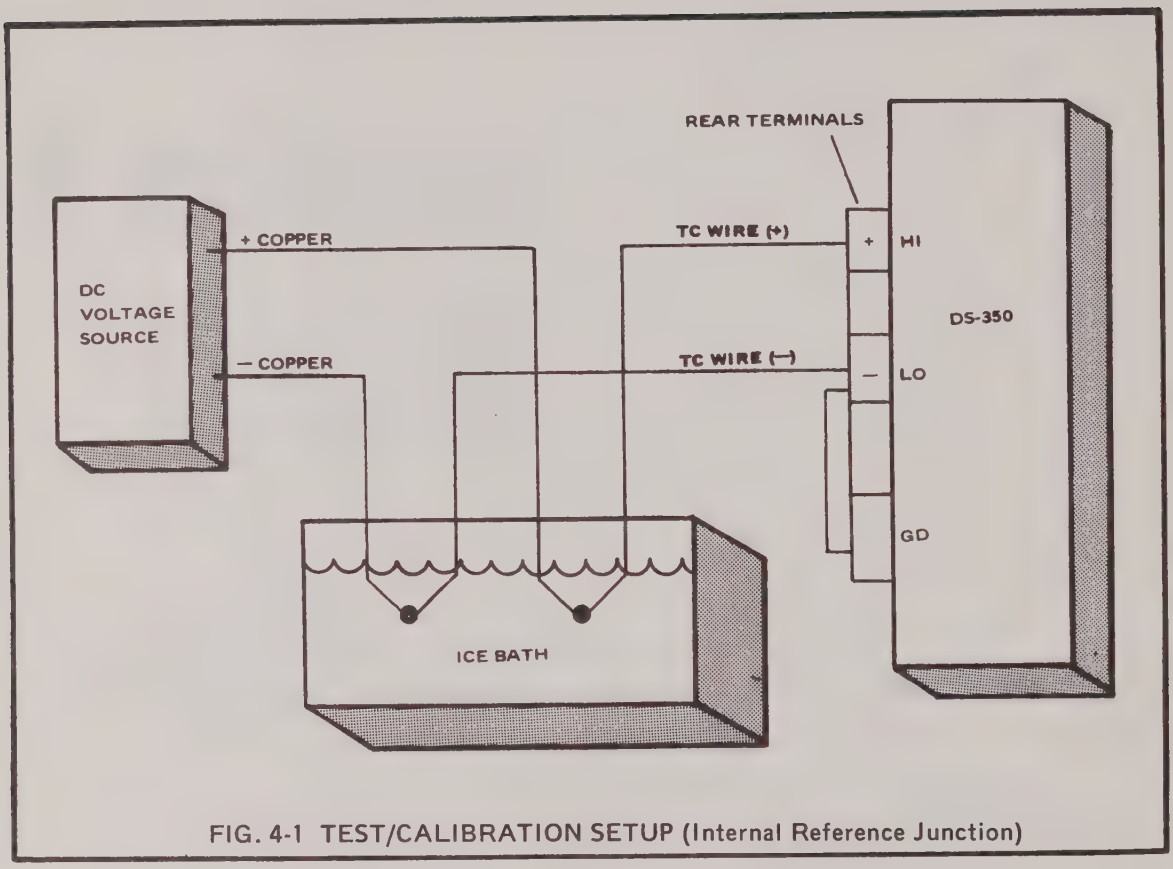


FIG. 4-1 TEST/CALIBRATION SETUP (Internal Reference Junction)

NOTE: To gain access to calibration controls as shown in Figure 4-2, remove the two screws from the center of the rear panel. This will make the inner portion of the DS-350-T3 mobile. The inner portion may then be pushed forward, with the power cable and test wires attached, until the three pots are accessible.

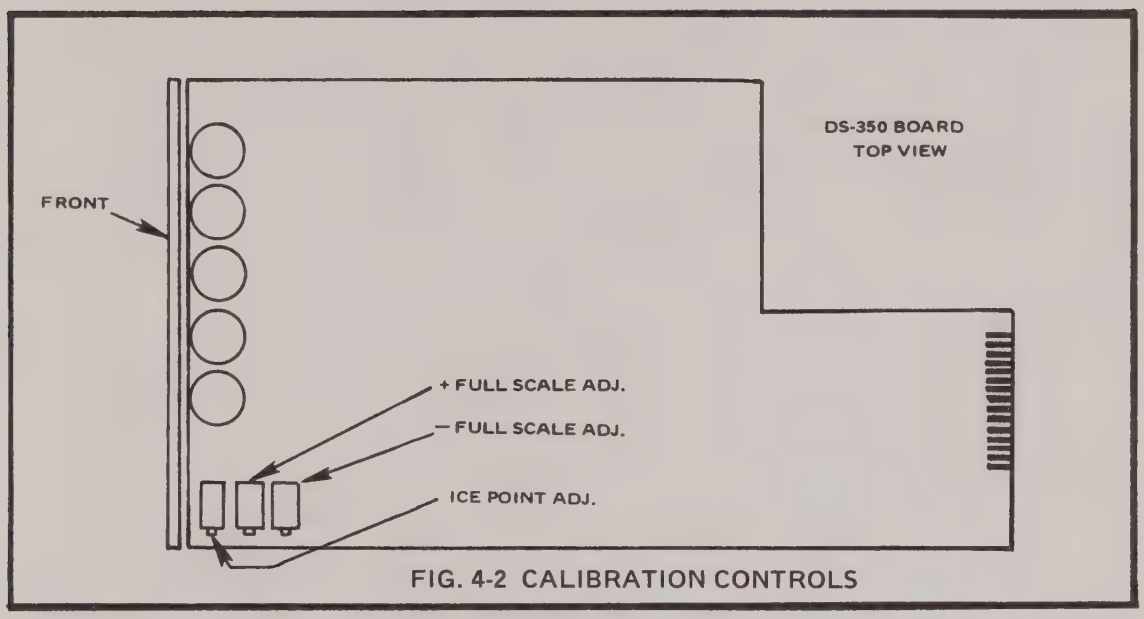


FIG. 4-2 CALIBRATION CONTROLS

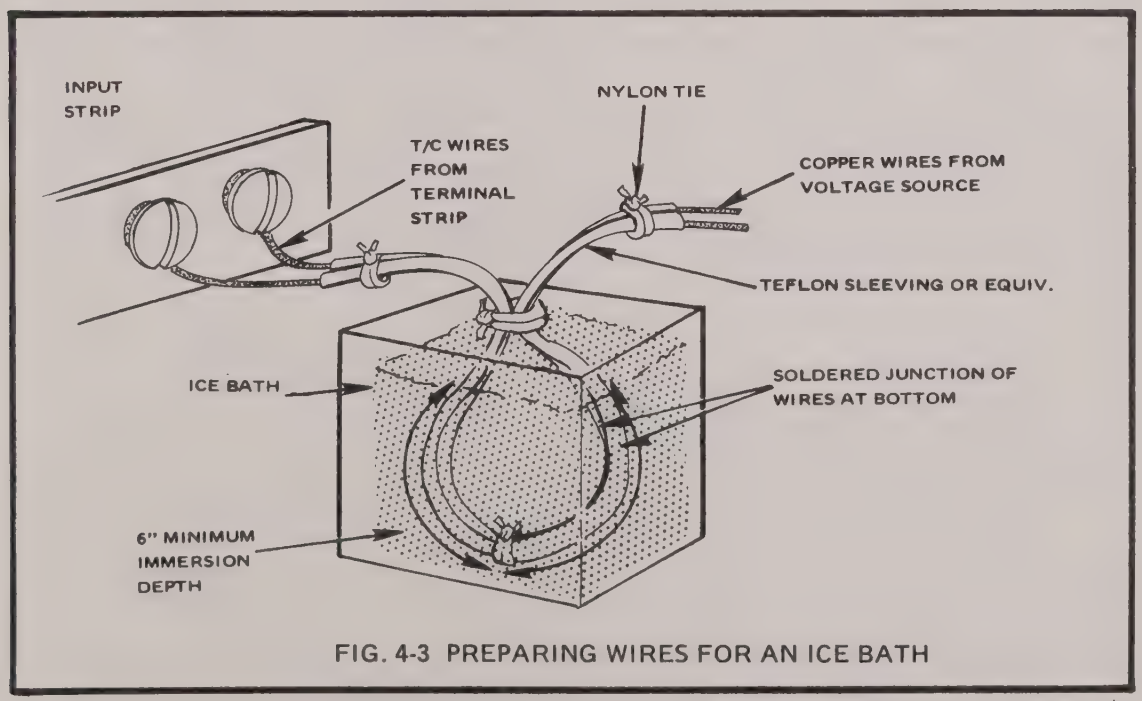


FIG. 4-3 PREPARING WIRES FOR AN ICE BATH

DS-350 CALIBRATION CHART FOR INSTRUMENTS WITH INTERNAL REFERENCE JUNCTIONS

T/C Range Spec.	Range Degrees	Input MV	Adjust Poten.	*Read Degrees	Input MV	Adjust Poten.	*Read Degrees	Input MV	Adjust Poten.	*Read Degrees
K201	-40 to +2400°F	0.000	zero	32.0	52.939	+F. S.	2399.9	-1.527	-F. S.	-39.9
K202	-60 to +1370°C	0.000	zero	000.1	54.807	+F. S.	1370.0	-2.243	-F. S.	-59.9
J201	0 to +1600°F	0.000	zero	32.0	50.059	+F. S.	1599.9	N/A	N/A	N/A
J202	-200 to +750°C	0.000	zero	000.0	42.283	+F. S.	750.0	-7.890	-F. S.	-199.7
J203	-320 to +800°F	0.000	zero	32.0	23.317	+F. S.	800.1	-7.791	-F. S.	-319.9
T201	-320 to +750°F	0.000	zero	32.1	20.801	+F. S.	750.0	-5.532	-F. S.	-319.9
T202	-200 to +400°C	0.000	zero	000.1	20.869	+F. S.	400.0	-5.603	-F. S.	-199.8
T203	-160 to +480°F	0.000	zero	32.0	11.949	+F. S.	480.0	-3.565	-F. S.	-159.9
E201	-280 to +1800°F	0.000	zero	31.6	75.024	+F. S.	1800.1	-8.069	-F. S.	-279.9
E202	-220 to +1000°C	0.000	zero	000.0	76.358	+F. S.	1000.5	-9.274	-F. S.	-219.7
R201	0 to +3100°F	0.000	zero	31-	20.275	+F. S.	3100-	N/A	N/A	N/A
R202	0 to +1600°C	2.400	zero	300.1	18.842	+F. S.	1599.9	N/A	N/A	N/A
R203	+640 to +1280°C	6.040	zero	640.0	14.343	+F. S.	1280.0	N/A	N/A	N/A
S201	0 to +3200°F	0.000	zero	31-	18.612	+F. S.	3200-	N/A	N/A	N/A
S202	0 to +1600°C	2.323	zero	300.0	16.771	+F. S.	1600.0	N/A	N/A	N/A
S203	+640 to +1280°C	5.648	zero	640.0	12.913	+F. S.	1280.0	N/A	N/A	N/A

*Standard Ranges. For other ranges, refer to current NBS Thermocouple Calibration Tables.

EXAMPLE: For Type K201: Attach compensated calibrator (Figure 4-1) to HI and LO T/C inputs on the DS-350. Apply 0.000 mv and adjust the zero pot for a readout of 32.0°F. Apply 52.939 mv to the DS-350 T/C input. Adjust the +F. S. Pot for a readout of 2399.9°F.

Note that a small interaction between the zero and +F. S. Pot may be present. Repeat the above steps if this observed.

Apply -1.527 mv to the DS-350 and adjust the -F. S. Pot for -39.9°F.

* Readings required for calibration may vary by small mounts from nominal.
This is intentional, since it "centers" the linearizer errors equally around the thermocouple curve.

FIG. 4-4 CALIBRATION CHART FOR INSTRUMENTS HAVING INTERNAL REFERENCE JUNSTIONS

4.3 CALIBRATION PROCEDURE

(For Instruments Having External Reference Junctions)

To calibrate an instrument having an external 32° or 150° reference junction, hook up equipment as shown in Figure 4-5 and follow the instructions below'

Since it is a Doric policy to provide additional corrective offset voltages internally in the DS-350 for instruments ordered to work with external 150°F reference junctions, the same calibration voltages as listed in Figure 4-4 apply.

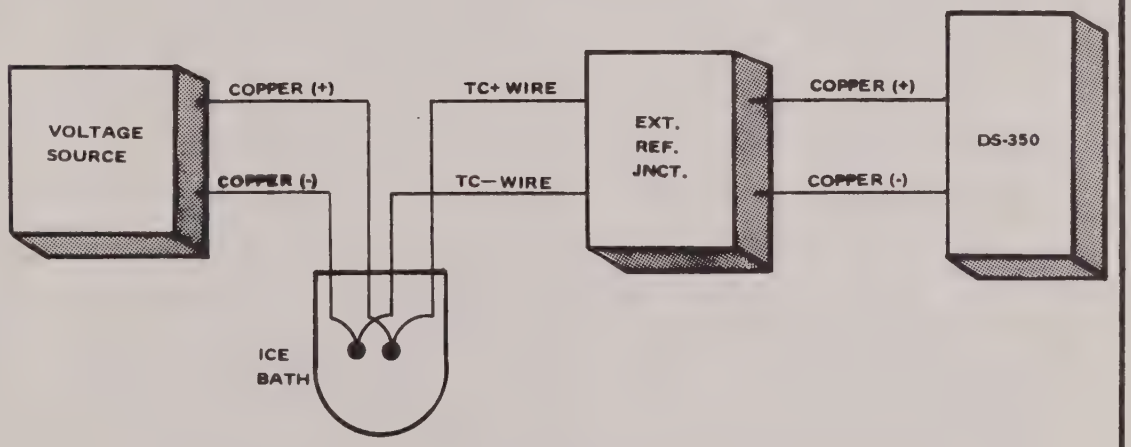


FIG. 4-5 EXTERNAL REFERENCE JUNCTION CALIBRATION

4.4 COMPUTER CALIBRATION TABLES

Calibration Tables — Gives Extra Accuracy: Supplied free of charge with each DS-350 delivered, this comprehensive, multi-page computer printout gives valuable error analysis data which can be used to further improve on the basic instrument accuracy. A portion of the five column table is shown below. That portion shown advances in 10° increments. The tables you receive are in 5° increments.

Front, left to right, the first two columns are merely temperature versus millivolts from the NBS Tables. The third column shows exact + or - error in millivolts due to linearization. The fourth column converts column 3 to degrees. The fifth column results from a polynomial describing the worst case error band on all Doric errors, fixed and variable, at each 5° increment. The instrument is never worse. Our composite "accuracy" in Table I represents the worst error throughout the entire range. In fact, most Doric instruments track **Column 4** within 0.1°.

Accuracy and Honesty: Doric's policy has always been to quote accuracy on thermocouple indicators which is the **total error band** due to all factors, relative to the NBS Tables. We interchangeably refer to this as "accuracy" or "conformity." As the pioneer and industry pace-setter in this field, we breed competition, some healthy, some unethical. Some of our "shyster" competitors refer to "conformity" in a different manner altogether, shading the issue but without offering an explanation. Separating out the errors due to linearization from the digitizing errors and reference junction errors seems a bit dishonest to us. An error is an error. Let's add them all up and quote a total error specification. If you want to know our "linearization" errors, we give you a several page computer printout free-of-charge showing the exact + or - linearity deviation from the NBS Tables at every 5° increments.

Column 1	Column 2	Column 3	Column 4	Column 5
TEMP	TABLE MV.	ERROR MV.	ERROR DEG	ERROR CON
-20.0	-.7700	.0013	.0327	.1244
-10.0	-.3900	-.0037	-.0974	.2065
0	0	.0012	.0312	.1158
10.0	.4000	.0025	.0625	.1585
20.0	.8000	.0037	.0924	.1982
30.0	1.2000	-.0012	-.0309	.1202
40.0	1.6100	.0038	.0908	.1986
50.0	2.0200	.0002	.0043	.0881
60.0	2.4300	-.0034	-.0824	.1917
70.0	2.8500	.0033	.0801	.1907
80.0	3.2600	.0000	.0006	.0881

4.5 TROUBLESHOOTING

4.5.1 Introduction

It is unlikely that your Doric instrument will need any repairs during its lifetime. In case the situation does arise, a novel program of trouble analysis has been worked out which is both effective and easy to follow. After the program will be found voltage charts and hold condition checkout chart.

4.5.2 Notes on Circuit Analysis

Once a fault has been isolated to a given circuit, the following steps should be taken before replacing components:

a. Check the theory of operation, Section III, and circuit description section given in fault isolation program. This will tell what the circuit is supposed to do and how it should operate;

b. Analyze the input waveform for proper voltage levels and rise or fall times.

c. Check for abnormal loads on circuit in question. The schematic will help in finding what the normal load is.

d. Trace signal path in the circuit, component by component, with an ohmmeter to ensure that there are no abnormal opens or shorts.

e. Replace bad components as required.

4.5.3 Troubleshooting Programs

The following pages contain the programs, which, when worked through systematically, will locate a malfunction in any part of the instrument. Each initial item in each sequence contains a question, the answer to which is a simple yes or no. Each answer leads to the next step or path in the program, logically eliminating each possibility until the trouble is located.

Nominal Voltage	Actual Voltage	Load Resistance (Analog Section)	Load Resistance (Digital Section)
-28V	-24V to -30V	> 280 Ω	
+28V	+24V to +30V	> 3.4K	
+15V	+14.7V to +15.7V	> 1K	
-15V	-14.0V to -15.0V	> 1K	
+6.33V (Precision)	6.33V ± 0.1 volts	—	—
-6.33V (Precision)	-6.33V ± 0.05 volts	—	—
+5V	+5 ± .25V		> 300 Ω
+190V	+190V ± 20V		> 40K

FIG. 4-6 NORMAL POWER SUPPLY VOLTAGES AND LOAD RESISTANCES

NOTE: Load resistances should be measured with the power off. All load resistances should be measured with respect to applicable ground. The ohmmeter terminal must have the same polarity as the power supply being measured. These measurements are to be made with an ohmmeter having a 1.5V voltage source, and set on RX100 scale.

Digital		
Logic Level	Logic State	Step No.
S. R. G. (Q3)	0	99
L_1	0	8
L_0	0	8
L_R	0	8
L_Z	1	8

Analog		
Analog Test Pin	Voltage	Step No.
Q_4 FET Input	0V	100
Integrator Out	-.6V ± .2V	101
Zero Amp Out	-5V ± 5V	102
Auto-Zero	0 ± 5V	103
D_1 (Q12)	-15V	100
D_2 (Q13)	0	100
D_3 (Q14)	+15V	100
D_5 (Q15)	-15V	100
D_6 (Q17)	-15V	100

NOTE: The Auto-Zero condition is set by applying +5V to R26 or grounding Q3 collector. Disconnect this line after Auto-Zero test.

Logic State "0" corresponds to 0V to + .8V Rel. to Digital Ground.

Logic State "1" corresponds to 2.4V to 5.0V Rel. to Digital Ground.

FIG. 4-7 AUTO-ZERO CONDITION CHECKOUT CHART

FAULT ISOLATION PROCEDURE

STEP NO.	PROCEDURE	IF YES GO TO NUMBER	IF NO GO TO NUMBER
1	Are all power supplies OK per Figure 4-7?	6A	2
2	Are all loads normal per Figure 4-7?	3	6
3	Are fuses OK?	5	4
4	Replace fuses. Return to Step 1.	—	—
5	Analyze bad power supply; correct fault and return to Step 1.	—	—
6	Analyze incorrect load; correct fault; return to Step 1.	—	—
6A	Do all Digital Integrated Circuits receive +5 volt and Dig. Ground Services?	2	6B
6B	Analyze supply path; restore continuity and go to Step 2.		
7	Set meter in Auto-Zero mode. Apply 5V to end of R26 near TP3 and check if circuit condition agrees with Figure 4-8. Remove Auto-Zero Mode after check.	8	Go to step shown in Chart 4-8
8	Apply a voltage source to the input. Go to Step 9.	—	—
9	Does L_1 oscillate?	10	29
10	Does $\overline{L_1}$ positive-going transition force $\overline{L_R}$ to 0?	11	26
11	Does $\overline{L_R} = 0$ cause $\overline{L_R} + R = 0$?	12	26
12	Does $\overline{L_R} + R = 0$ turn off Q15 or Q17?	13	72
13	Does Q15 or Q17 cause corresponding FET (Q22 or Q23) to turn on?	14	72
14	When integrator amp crosses thru -.6V, does it cause L_Z and $\overline{L_Z}$ to change state?	15	72
15	When L_Z and $\overline{L_Z}$ change states, does it reset L_R to 0 via dual differentiator?	16	93
16	Does $L_1 = 0$ and L_R resetting to 0 cause $L_0 = 0$ at L_0 Generator?	17	26
17	Does $L_0 = 0$ cut off counter pulses at Z31-2 via CR27?	18	26

FAULT ISOLATION PROCEDURE (Continued)

STEP NO.	PROCEDURE	IF YES GO TO NUMBER	IF NO GO TO NUMBER
18	Does L_0 resetting to 0 cause a sharp store pulse at collector of Q26?	19	26
19.	Does store pulse arrive at Pins 4 and 13 of Latches (Z5, Z11, Z15, Z18, Z25) and cause counter information to be transferred to storage registers?	?	?
20	End of encoding sequence.		
21	Remove Z13 or isolate Z13, Pin 9 by removing solder from it on bottom of board and centering pin. (Turn off power while doing this.) Restore power. Does 32 kHz appear on Z37-7?	22	24
22	Replace integrated circuit with new unit. Go to Step 23.	—	—
23	Does Z28-8 oscillate?	30	48
24	Remove Z22 or isolate Z22-5. Does 32 kHz appear on Z37-7?	22	25
25	Remove Z32 (do <u>not</u> try to isolate pins). Does 32 kHz appear on Z37-7?	22	25A
25A	Replace Z37. Does 32 kHz appear on Z37-7?	23	1
26	Are waveforms from previous circuit OK?	27	28
27	Check operation of circuit in question using circuit description; correct fault and return to the step taken prior to Step 26.	—	—
28	Check operation of previous circuit using circuit description; correct fault and proceed along "Yes" route.	—	—
29	Does input to Z28 Pin 8 oscillate?	30	120
30	Is L_0 true?	31	39
31	Is Q3 collector false?	32	38
32	Is $\overline{L_1}$ true and L_1 false?	33	38
33	Is Z20 Pin 13 true?	34	36
34	Is L_0 now false?	9	38
35	Change Z20 and go to Step 33.	—	—

FAULT ISOLATION PROCEDURE (Continued)

STEP NO.	PROCEDURE	IF YES GO TO NUMBER	IF NO GO TO NUMBER
36	Force L_R to be false; is Z20 Pin 13 true?	37	35
37	Repair L_R circuit and return to Step 33.	—	—
38	Analyze circuit, correct fault, and return to previous step.	—	—
39	Is Q3 collector true?	40	38
40	Is flip-flop $\overline{L_1}$ false and L_1 true?	41	38
41	Is Z20 Pin 13 false?	42	38
42	Is L_0 now true?	9	38
43	Is clock signal present on Z37-9?	21	44
44	Analyze and restore continuity from clock to Z37-9. Does 32 kHz appear on Z37-7?	48	21
45	Unassigned.		
46	Does 2.05 mHz clock oscillate?	47	38
47	Does 32 kHz appear on Z37-7?	48	43
48	Does 32 kHz appear on Z22-5?	49	55
49	Remove jumper between A7 & A9. Does a frequency between 240 kHz and 537 kHz appear on Z32-6?	50	57
50	Does this high frequency appear on Z22-12?	51	55
51	Is the logic level on Z22-11 opposite that on Z22-6?	52	56
52	Is logic level on Z22-11 true?	53	54
53	Trace 32 kHz thru Z22-1, Z29-9, Z29-5 (16 kHz), Z23-9, Z23-5 (8 kHz), CR28 and C11. Analyze signal path & replace components as needed. Go to Step 60.	—	—
54	Trace High Frequency (240-537 kHz) thru Z22-1, Z29-9, Z29-5 (÷2), Z23-9, Z23-5 (÷2), CR28 and C11. Analyze signal path & replace components as needed. Go to Step 60.	—	—
55	Check & restore continuity along strap path. Go to Step 50.	—	—
56	Replace Z20; if logic level on Z22-11 & Z22-6 are still the same, replace Z22. Go to Step 51.	—	—

FAULT ISOLATION PROCEDURE (Continued)

STEP NO.	PROCEDURE	IF YES GO TO NUMBER	IF NO GO TO NUMBER
57	Does clock reach Pin 9 on Z32 & Z37?	58	59
58	Analyze Z32 & Z37 & replace as needed. Go to Step 49.	—	—
59	Analyze & correct continuity on strap. Go to Step 57.	—	—
60	Is L_0 true?	61	65
61	Does frequency on CR28 appear on Z31-2?	62	68
62	Does frequency on Z31-2 appear on Z4-14?	63	69
63	Are Pins 2-3 on Z4, Z10, Z14, Z17 & Z24 false?	64	70
64	Trace frequency on Z4-14 thru counters Z4, Z10, Z14, Z17 & Z24. The carry output of each counter should equal input of that counter divided by 10. Replace counters and loads Z3, Z9, Z30 & Z41 as necessary. Remove cathode (Band End) of CR27 from Board. Go to Step 110.	—	—
65	Are either L_1 (TP15) or L_R (TP6) or both, logically true?	66	67
66	Replace Z20. Go to Step 60.	—	—
67	Disconnect cathode (Band End) of CR27 from circuit board. Go to Step 61.	—	—
68	Analyze & replace Z31 or CR28 as required. Go to Step 61.	—	—
69	Analyze & restore continuity between the two points; go to Step 62.	—	—
70	Clamp Pins 2 & 3 on counters false; go to Step 63.	—	—
71	Unassigned	—	—
72	Is integrator amplifier more positive than -.5V?	84	73
73	Is zero amplifier output approximately -13V?	74	88
74	Is Pin 10 of Z27 true?	75	89
75	Is L_R true?	76	11
76	Is L_Z in opposite state to Pin 10 of Z27?	77	86

FAULT ISOLATION PROCEDURE (Continued)

STEP NO.	PROCEDURE	IF YES GO TO NUMBER	IF NO GO TO NUMBER
77	Is $\overline{L_Z}$ in opposite state to L_Z?	78	87
78	Does $\overline{L_R}$ + R go low when L_R fires?	79	26
79	Is L_Z false?	80	81
80	Is Q22 on?	13	83
81	Is Q17 on?	13	82
82	Analyze Q17 circuit, correct fault, and return to Step 13.	—	—
83	Analyze Q15 circuit, correct fault, and return to Step 13.	—	—
84	Is output of zero amplifier approximately 0V?	85	88
85	Is Pin 10 of Z27 false?	75	89
86	Check Z27, correct faults, and return to Step 76.	—	—
87	Check Z27, correct faults, and return to Step 77.	—	—
88	Analyze zero amplifier, correct faults, and return to Step 73 or Step 84.	—	—
89	Analyze Z27, correct fault, and return to Step 74 or Step 85.	—	—
90-92	Unassigned	—	—
93	Is D4 oscillation reaching Pin 11 of Z31?	94	96
94	Is there a negative differentiated pulse on Pin 6 of Z21?	95	97
95	Does $\overline{L_R}$ go true?	16	98
96	Trace oscillation through feedthrough circuit straps, etc., correct fault, and return to Step 93.	—	—
97	Analyze dual differentiator, correct fault, and return to Step 94.	—	—
98	Analyze L_R - $\overline{L_R}$ flip-flop, correct fault, and return to Step 95.	—	—
99	Refer to Section III, Paragraph 3.4.5 for Theory of Operation. Go to Step 8.	—	—

FAULT ISOLATION PROCEDURE (Continued)

STEP NO.	PROCEDURE	IF YES GO TO NUMBER	IF NO GO TO NUMBER
100	Refer to Section III, Paragraph 3.4.4, Analog Switching. Go to Step 104.	—	—
101	Refer to Section III, Paragraph 3.4.6, Integrating Amplifier. Go to Step 106.	—	—
102	Refer to Section III, Paragraph 3.4.7, Zero Crossing Amplifier. Go to Step 107.	—	—
103	Refer to Section III, Paragraph 3.4.9, Auto-Zero Circuit. Analyze circuit and correct fault.	—	—
104	Are the inputs to the analog switches OK? ($\overline{L_1}$ - HIGH; L_1 - LOW; L_R - LOW; L_Z - LOW; $\overline{L_R}$ + R - HIGH)	105	8
105	Analyze circuit in question, correct fault, and return to Figure 4-8.	—	—
106	Is connection of Gate of Q8 and end of C22 positive?	26	72
107	Is Pin 6 of integrator amplifier -.6V ±2V?	26	72
108-109	Unassigned.	—	—
110	Does frequency on Pin 11 of Z14 ("80") appear (as spikes) on Z28-8 (i.e., does Z28-8 oscillate?)	112	111
111	Analyze continuity between Z14-11 and Z28-8, including C14 & R33. Replace components, etc., as necessary. Go to Step 110.	—	—
112	Do frequencies on Z10-11, Z14-1 and Z14-11 appear at respective feed-thrus (29, 30); (27, 28); and (25, 26)? Note: Only those frequencies for which feed-thrus are present need be analyzed.	113	119
113	Does frequency on Z14-9 appear on Z9-8?	114	119
114	Does frequency on Z14-11 appear on Z9-9?	115	119
115	Does an output frequency appear on Z9-13?	116	132
116	Does an output frequency appear on Z3-4?	117	132
117	Does frequency on Z3-4 appear on Z39?	118	119
118	Check/Force RS2 Line to Logic True. Check that each flip-flop in preset frequency counter (Z29, Z34, Z39) divides its input frequency by 2. Analyze & replace flip-flops as necessary. Go to Step 133.	—	—

FAULT ISOLATION PROCEDURE (Continued)

STEP NO.	PROCEDURE	IF YES GO TO NUMBER	IF NO GO TO NUMBER
119	Analyze & restore continuity between the two points in question & go back to the step you were on before this one.	—	—
120	Is Z31-8 true?	121	125
121	Is Z31-9 false?	122	124
122	Is L_0 true?	123	129
123	Analyse sample rate generator malfunction; correct fault, and go to Step 127.	—	—
124	Replace Z31 and go to Step 127.	—	—
125	Remove Q38. Now does Z28-8 oscillate?	126	128
126	Install new Q38 and go to Step 127.	—	—
127	Now does Z28-8 oscillate?	30	46
128	Re-install Q38 and go to Step 46	—	—
129	Is L_1 true?	130	131
130	Replace Z20. Go to Step 122.	—	—
131	Replace Z28. Go to Step 122.	—	—
132	Replace the integrated circuit which fails to have output frequency & return to step you were on previous to this one.	—	—
133	Do inputs to zero address detector receive frequencies from segment counter?	134	119
134	Does Z40-1 have an output frequency?	135	132
135	Do inputs to Z33 receive frequencies from the segment counter?	136	119
136	Do Pins 3, 6, 8, & 11 of Z33 have output frequencies?	137	132
137	Do Pins 10, 11, 12, 13 & 14 have input frequencies?	138	119
138	Do inputs to 9th bit generator receive frequencies?	139	119
139	Is an output frequency present on line which picks up feed-thrus 40, 41 & 42?	140	132
140	Replace band end of CR27 in board. Go to Step 29.	—	—

parts lists; schematics

DSO-350

Doric P/N	Description	Mfr	Mfg #	Qty	Rec Spares	Unit Cost
100-703-01	Guard crossing transformer			4	1	$ 1.00
900-081-03	.001 mfd disc cap 1000V	Sprague		1		.25
901-012-21	220 pf disc cap 1000V	Sprague		7		.25
911-036-83	.068 mfd 100V polycarb. cap	IMB		2		1.20
942-201-02	Resistor ¼w 5% carbon 1K	Allen Bradley		1		.20
942-201-53	Resistor ¼w 5% carbon 15K	Allen Bradley		5		.20
942-202-21	Resistor ¼w 5% carbon 220 ohm	Allen Bradley		3		.20
942-203-32	Resistor ¼w 5% carbon 3.3 K	Allen Bradley		1		.20
942-203-91	Resistor ¼w 5% carbon 390 ohm	Allen Bradley		1		.20
942-203-92	Resistor ¼w 5% carbon 3.9 K	Allen Bradley		5		.20
942-204-72	Resistor ¼w 5% carbon 4.7 K	Allen Bradley		5		.20
942-206-81	Resistor ¼w 5% carbon 680 ohm	Allen Bradley		2		.20
961-075-11	Diode	Continental Devices	1N751A	1	1	.70
961-091-40	Diode	Continental Devices	1N914	6	2	.15
962-341-50	Transistor	General Electric	2N3415	6	1	1.00
962-363-80	Transistor	Carter	2N3638	1		1.00
965-515-00	Hex Inverter	Motorola	MC9718P	2		5.45
967-005-00	Choke 240 microhenry			1		1.00
973-080-01	Varicon pins	Elco	02-060-114-620	14		.15
965-520-00	Integrated circuit	Signetics	SN74107	1		1.30
100-721-01	Doric spec zener diode			1		16.25
100-722-02	FET low leak	Amelco	U1742	2	1	1.25

DS-350 (Continued)

Doric P/N	Description	Mfr	Mfg #	Qty	Rec Spares	Unit Cost
100-725-01	Dual FET	Solitron	U1742	1		$19.75
100-733-00	FET	Intersil	1TS3200	2		1.10
100-733-00	Dual NPN		TP 710	1		5.50
210-703-00	Inductor			1		1.50
210-707-00	FET		U2567E	2		1.50
900-021-04	.01 mfd disc cap, 500V	Sprague		12		.25
900-081-03	.001 mfd disc cap, 1000V	Sprague		10		.25
900-081-05	.0015 mfd disc cap, 1000V	Sprague		1		.25
900-082-03	.002 mfd disc cap, 1000V	Sprague		8		.25
900-085-03	.005 mfd disc cap, 1000V	Sprague		1		.25
901-011-01	100 pf disc cap, 1000V	Sprague		1		.25
901-012-20	22 pf disc cap, 1000V	Sprague		2		.25
901-082-02	.02 mfd disc cap, 1000V	Sprague		1		.50
910-061-07	100 mfd 250V cap	Sprague		1	1	2.25
910-200-35	200 mfd 35V electrolytic	Mallory		2		1.00
910-801-16	8000 mfd 15V	Mallory		1		2.50
911-032-24	.22 mfd 100V polycarb cap	IMB		3		1.70
911-033-32	.033 mfd 100V polycarb cap	IMB		1		2.35
911-034-73	.047 mfd 50V polycarb cap	IMB		1		2.05
911-036-83	.068 mfd 100V polycarb cap	IMB		1		1.20
913-042-24	.22 mfd 50V polystyrene cap	IMB		1		1.90

DS-350 (Continued)

Doric P/N	Description	Mfr	Mfg #	Qty	Rec Spares	Unit Cost
915-032-21	220 pf Durmica cap	Durmica		3		$ .65
915-034-70	47 pf Durmica cap	Durmica		1		.60
916-010-05	1 mfd 50V tantalum	Sprague	196D	2		1.50
916-220-05	22 mfd 35V tantalum	Sprague	196D	2		3.50
916-470-35	4.7 mfd 35V tantalum	Sprague	196D	1		1.40
920-351-11	5.11 K 1% RN60D resistor	IRC		1		.30
920-360-40	604 ohm 1% RN60D resistor	IRC		1		.30
920-410-02	10 K 1% RN60C resistor	IRC		2		.36
920-410-03	100 K 1% RN60C resistor	IRC		2		.36
920-412-12	12.1 K 1% RN60C resistor	IRC		1		.36
920-416-53	165 K 1% RN60C resistor	IRC		2		.36
920-416-92	16.9 K 1% RN60C resistor	IRC		2		.36
920-424-93	249 K 1% RN60C resistor	IRC		1		.36
920-429-92	24.9 K 1% RN60C resistor	IRC		1		.36
920-429-93	29.4 K 1% RN60C resistor	IRC		1		.36
920-475-01	7.5 K 1% RN60C resistor	IRC		1		.36
920-482-52	82.5 K 1% RN60C resistor	IRC		1		.36
920-490-91	9.09 K 1% RN60C resistor	IRC		1		.40
942-201-01	100 ohm ¼w 5% carbon resistor	Allen Bradley		2		.20
942-201-02	1 K ¼w 5% carbon resistor	Allen Bradley		13		.40
942-201-03	10 K ¼w 5% carbon resistor	Allen Bradley		6		.20

DS-350 (Continued)

Doric P/N	Description	Mfr	Mfg #	Qty	Rec Spares	Unit Cost
942-201-04	100 K ¼w 5% carbon resistor	Allen Bradley		3		$ .20
942-201-05	1 meg ¼w 5% carbon resistor	Allen Bradley		3		.20
942-201-24	120 K ¼w 5% carbon resistor	Allen Bradley		2		.20
942-201-51	150 ohm ¼w 5% carbon resistor	Allen Bradley		3		.20
942-201-52	1.5 K ¼w 5% carbon resistor	Allen Bradley		4		.20
942-201-53	15 K ¼w 5% carbon resistor	Allen Bradley		4		.20
942-201-54	150 K ¼w 5% carbon resistor	Allen Bradley		4		.20
942-202-20	22 ohm ¼w 5% carbon resistor	Allen Bradley		1		.20
942-202-22	2.2 K ¼w 5% carbon resistor	Allen Bradley		2		.20
942-202-23	22 K ¼w 5% carbon resistor	Allen Bradley		14		.20
942-202-24	220 K ¼w 5% carbon resistor	Allen Bradley		2		.20
942-202-25	2.2 meg ¼w 5% carbon resistor	Allen Bradley		1		.20
942-202-73	27 K ¼w 5% carbon resistor	Allen Bradley		1		.20
942-203-32	3.3 K ¼w 5% carbon resistor	Allen Bradley		3		.20
942-203-35	3.3 meg ¼w 5% carbon resistor	Allen Bradley		1		.20
942-203-91	390 ohm 5% carbon resistor	Allen Bradley		8		.20
942-203-92	3.9 K 5% carbon resistor	Allen Bradley		1		.20
942-204-72	4.7 K 5% carbon resistor	Allen Bradley		11		.20
942-206-22	6.2 K 5% carbon resistor	Allen Bradley		1		.20
942-206-81	680 ohm 5% carbon resistor	Allen Bradley		2		.20
942-206-82	6.8 K 5% carbon resistor	Allen Bradley		12		.20

DS-350 (Continued)

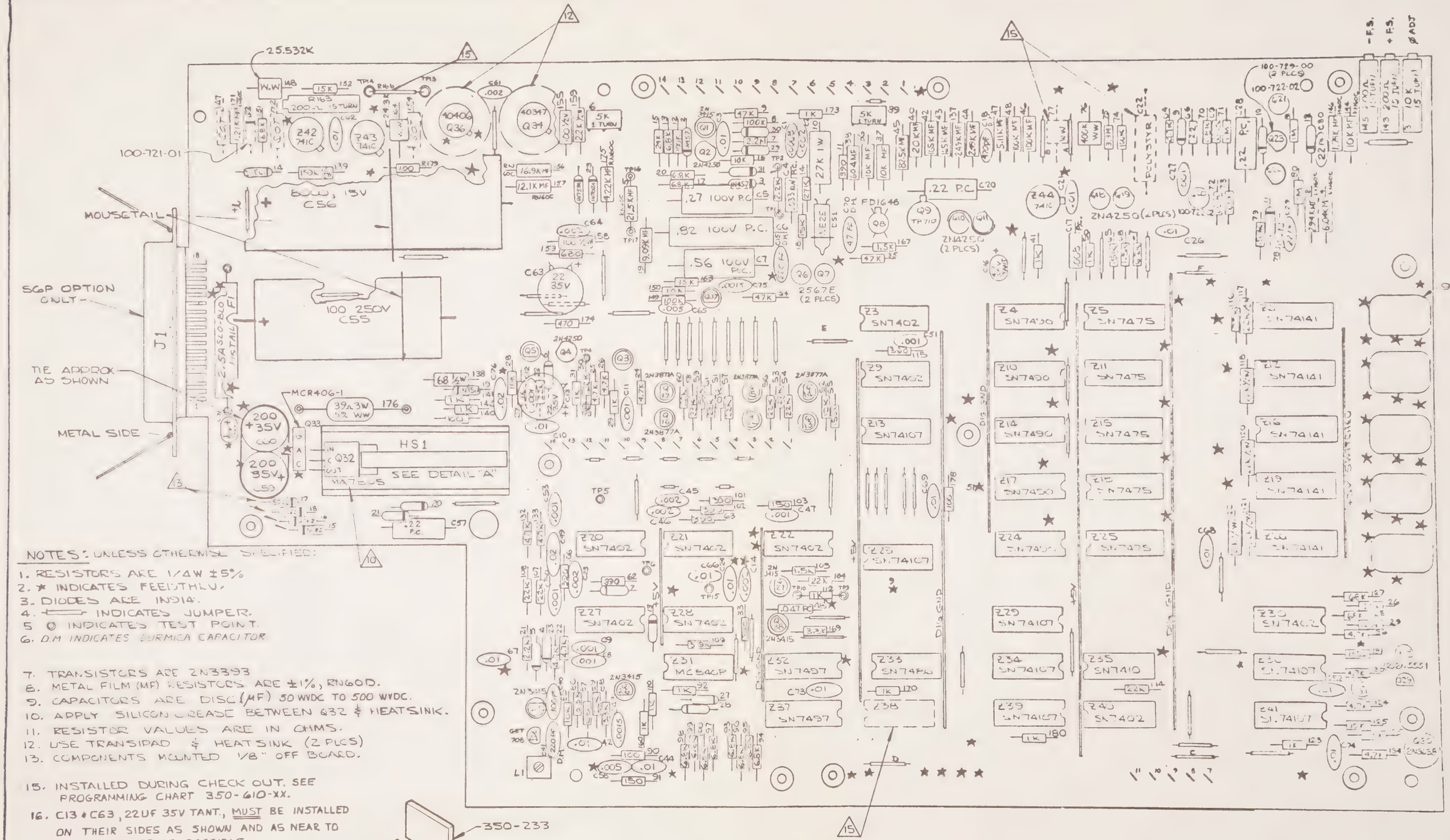
Doric P/N	Description	Mfr	Mfg #	Qty	Rec Spares	Unit Cost
942-206-83	68 K 5% carbon resistor	Allen Bradley		6		$ .20
942-206-84	680 K 5% carbon resistor	Allen Bradley		1		.20
942-207-53	75 K 5% carbon resistor	Allen Bradley		1		.20
942-302-22	2.2 K ½w 5% carbon resistor	Allen Bradley		1		.20
942-302-23	22 K ½w 5% carbon resistor	Allen Bradley		5		.20
942-203-33	33 K ¼w 5% carbon resistor	Allen Bradley		1		.20
942-204-73	47 K ¼w 5% carbon resistor	Allen Bradley		3		.20
960-011-05	10 K POT	Cermet		1		4.00
960-012-02	200 ohm Pot	Cermet		2		4.00
960-015-01	500 ohm Pot	Cermet		1		4.00
960-015-02	5 K Pot	Centralab	4 TR	2	1	1.50
961-045-70	1N457 Diode	Continental Devices	1N457	2	1	.45
961-070-20	1N702 Diode	Continental Devices	1N702	1		1.10
961-075-11	1N751A Diode	Continental Devices	1N751A	1		.70
961-091-40	1N914 Diode	Continental Devices	1N914	15	3	.15
962-339-30	2N3393 Transistor	Sprague	2N3393	7	1	1.00
962-341-50	2N3415 Transistor	GE	2N3415	5	1	1.00
962-360-60	2N3606 Transistor	GE	2N3606	1	1	1.00
962-363-80	2N3638 Transistor	Carter	2N3638	1	1	1.00
962-387-71	2N3877A Transistor	Sprague	2N3877	6	1	1.00
962-425-00	2N4250 Transistor	Carter	2N4250	6	1	1.00

DS-350 (Continued)

Doric P/N	Description	Mfr	Mfg #	Qty	Rec Spares	Unit Cost
964-040-00	40347 power transistor	RCA	40347	1	1	$ 2.60
964-040-02	40406 power transistor	RCA	40406	1	1	2.70
965-506-00	741 C Op Amp	Fairchild	741 C	3	1	2.70
965-516-00	SN 7402 Integrated Circuit	Signetics	7402	9	1	1.00
965-517-00	SN 7475 Integrated Circuit	Signetics	7475	5	1	2.25
965-518-00	SN 7490 Integrated Circuit	Signetics	7490	5	1	2.50
965-520-00	SN 74107 Integrated Circuit	Signetics	74107	7	1	1.30
965-521-00	SN 74141 Integrated Circuit	Signetics	74141	5	1	3.50
965-522-00	MC840P Integrated Circuit	Motorola	MC840P	1	1	1.60
965-532-00	SN 7410N Integrated Circuit	Signetics	7410	1	1	1.00
965-539-00	SN 7486 Integrated Circuit	Signetics	7486	1	1	1.60
965-549-00	Programmable ROM		N8223B	1		30.00
965-551-00	Regulator	Fairchild	7805	1		8.00
965-552-00	SN 7497 Integrated Circuit	Motorola	7497	2		15.00
966-002-00	200V Rectifier	Diodes, Inc.	SD2	4	1	.75
966-002-04	600V Rectifier	Diodes, Inc.	SD6	1	1	1.10
966-002-10	Rectifier	Motorola	MCR406-1	1	1	3.00
973-080-01	Elco pin	ELCO	02-060-114-620	45		.15
973-150-02	Connector	Amphenol	57-40360	1		8.00
991-001-01	Heatsink	Wakefield	2050B	2		.65
991-020-01	Standoff 7/8 x 4-40			8		.20

DS-350 (Continued)

Doric P/N	Description	Mfr	Mfg #	Qty	Rec Spares	Unit Cost
991-020-02	Standoff 1/8 x 4-40			1		$ .20
992-002-01	Tube socket	National	SK207	5		1.50
992-010-65	Buss Bar 13 Pin	Logic Dynamics		8		1.65
934-211-84	Resistor 400 K WW .05%	Jordan		1		7.50
971-070-07	Fuse 2. A Pigtail Slo-Blo	Littlefuse		1	1	.50
968-060-01	Display Tube	National	NL5750S	5	1	11.00
300-710-06	Power transformer	Electrical Windings				
968-010-03	Neon	GE	NE2E	1		.50
993-200-05	Power cord	Belden	17258B			5.00
500-211-XX	Front panel	Doric	500-211-XX	1		7.00
500-219-XX	Logo	Doric	500-219-XX	1		3.00
350-204-XX	Rear panel	Doric	350-204-XX	1		15.00
100-221-XX	Knob	Doric	100-221-XX	1		1.00
500-222-XX	Chassis	Doric	500-222-XX	1		35.00
900-086-83	.0068 mfd cap, 1000V	Sprague		1		.35



NOTES: UNLESS OTHERWISE SPECIFIED:

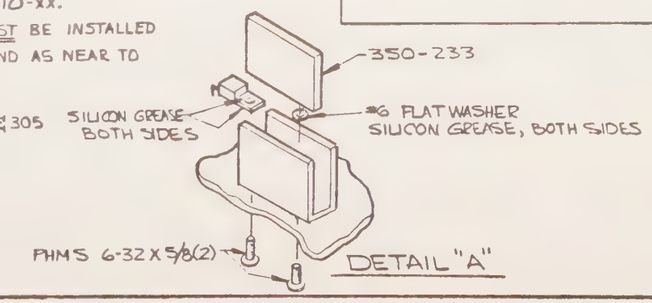
1. RESISTORS ARE 1/4W ±5%
2. ★ INDICATES FEEDTHRU.
3. DIODES ARE IN914.
4. ⟷ INDICATES JUMPER.
5. ⊙ INDICATES TEST POINT.
6. D.M INDICATES DURMICA CAPACITOR

7. TRANSISTORS ARE 2N3393
8. METAL FILM (MF) RESISTORS ARE ±1%, RN60D.
9. CAPACITORS ARE DISC (μF) 50 WVDC TO 500 WVDC.
10. APPLY SILICON GREASE BETWEEN Q32 & HEATSINK.
11. RESISTOR VALUES ARE IN OHMS.
12. USE TRANSIPAD & HEATSINK (2 PLCS)
13. COMPONENTS MOUNTED 1/8" OFF BOARD.

15. INSTALLED DURING CHECK OUT. SEE PROGRAMMING CHART 350-610-XX.

16. C13 & C63, 22UF 35V TANT., MUST BE INSTALLED ON THEIR SIDES AS SHOWN AND AS NEAR TO BOARD SURFACE AS POSSIBLE.

17. CABLE CONNECTION BETWEEN 350 & 305 SEE DWG. 350-415-XX



MOTHER BOARD, DS-350
ASSEMBLY 350-402-08

REF JUNCTION ASSY

OPTION BOARD

J1-34

J1-33

+15V

SIG DN

SIG UP

BREAK DETECT

EXTRA FILTER BIT

-15V

-6.33V PREC

RJ LO

GUARD PLANE

UNASSIGN

DUAL-SLOPE INTEGRATOR

ZERO DETEC

HIGH SPEED BREAK DETECTOR

L2 & DUAL DIFF

SAMPLE RATE GENERATOR

LO GENERATOR

L1 GENERATOR

LR GENERATOR

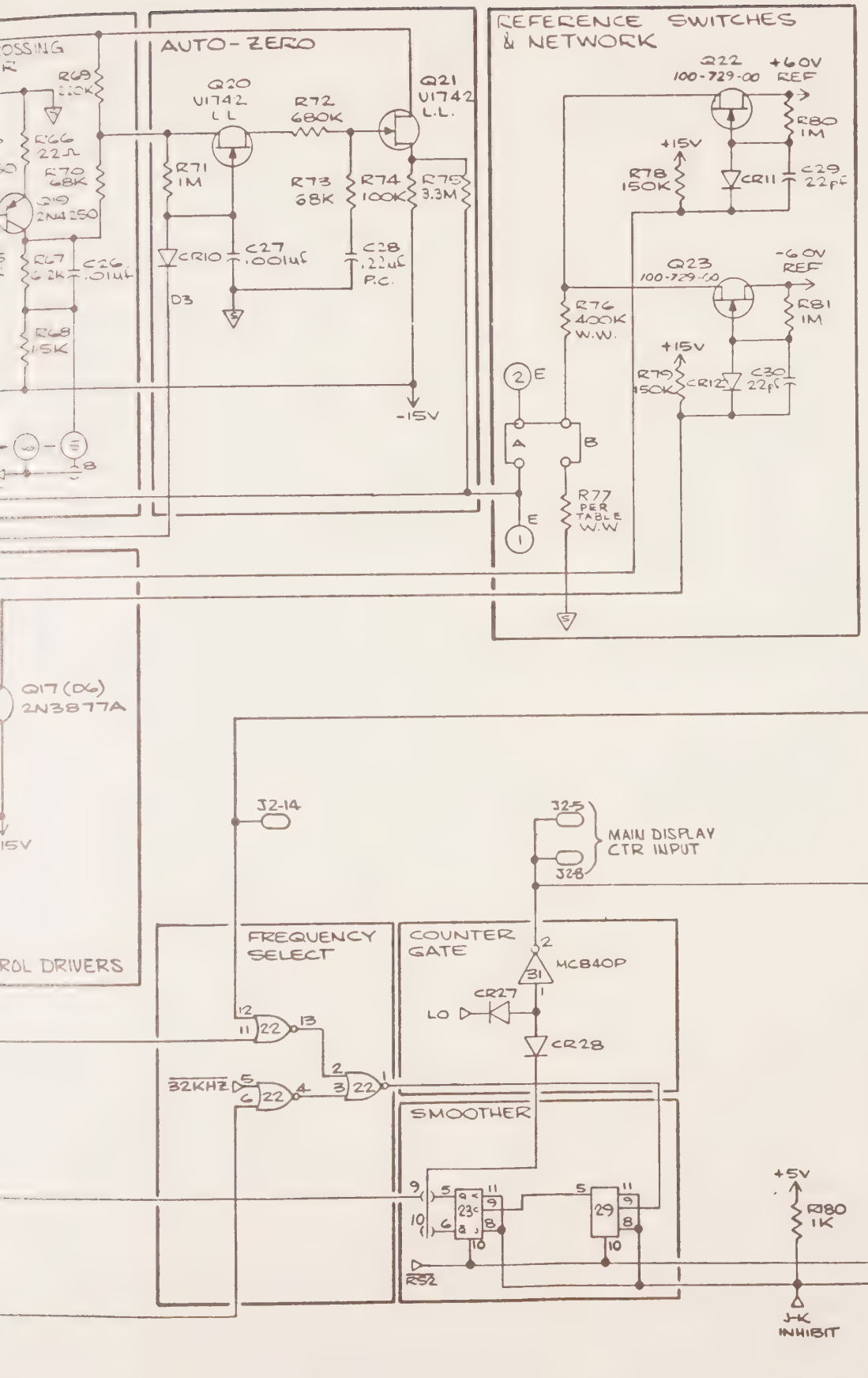
MC840P

TO Z1-13

J2-13 (USE TP6)

J2-12 (USE TP15)

J2-9 TP5


CROSSING
AUTO-ZERO
REFERENCE SWITCHES & NETWORK
Q20 U1742 L.L.
Q21 U1742 L.L.
Q22 100-729-00 +6.0V REF
Q23 100-729-00 -6.0V REF
R69 2.10K
R66 22Ω
R70 68K
Q19 2N4250
R67 6.2K
C26 .01uf
R68 15K
R71 1M
R72 680K
R73 68K
R74 100K
R75 3.3M
CR10
C27 .001uf
C28 .22uf P.C.
D3
-15V
R78 150K
CR11
C29 22pf
R80 1M
R76 400K W.W.
R79 150K
CR12
C30 22pf
R81 1M
R77 PER TABLE W.W
+15V
Q17 (D6) 2N3877A
ROL DRIVERS
2.050 MHZ CLOCK
+5V
C40 100pf
R85 10K
L1
C41 220pf D.M
R88 3.3K
C42 .01uf
C43 .0015uf
Q24 GET706
Q25 2N3415
C44 .01uf
R92 1K
MC840P
R90 100Ω
R91 150Ω
R86 3.3K
R87 680Ω
R89 22K
RESET GENERATO
C45 .002uf
C46 .002uf
L1
LR
R101 390Ω
R102 390Ω
B
15
+5V
10 11 12 13 9 6 5 7
16 37 SN7497 8 3 2 15 14 1 4
10 11 12 9 5 7 13 6
32 SN7497 3 2 15 1 4 14 8
16
32KHZ
C50 .001 uf
R106 LO 390Ω
C49 .02 Mf
R107 22K
R108 22K
STORAGE
ROW A
RANGE SELECT
J1-35
OPTION BOARD
B
10
40/60
80
LR
C
+5V
J1-36
RANGE INDICATE
STORE
LZ
LS.R
+8.5V UNREG
R93
R94
R95
R96
R97
R98
R99
R100
6.8K (8 PLCS)
9th BI
R114 22K
35
33
34
36
37
40/60 GENERATO
R115 390Ω
C51 .001MF
20
PLUS
MINUS
80 100°
10 20°
8 10°
LZ
LZ
9 7 6 5 4 3 2 1
38 B223 P.R.O.M. 8
15 14 13 12 11 10
J2-14
J2-5
J2-8
MAIN DISPLAY CTR INPUT
FREQUENCY SELECT
COUNTER GATE
MC840P
CR27
LO
CR28
32KHZ
SMOOTHER
RST
+5V
R80 1K
J-K INHIBIT
SN7486
(16 BIT)
(8 BIT)
(4 BIT)
(2 BIT)
(1 BIT)
PRESET SEGMENT COUNTER
ZERO ADDRESS DETECTOR
PLUS
MINUS

ERATOR

STORAGE DRIVER

9th BIT GENERATOR

ERATOR

SEGMENT 40/60 GENERATOR

RESS

SYMBOL BLOCK

NE2H LAMP
1 OF 2 PLCS
WITH OPTIONS ONLY

DIGITAL BUS DECOUPLING

DISPLAY COUNTER

NORMALLY IN PLACE

POLARITY AND OVERFLOW "1" DISPLAY

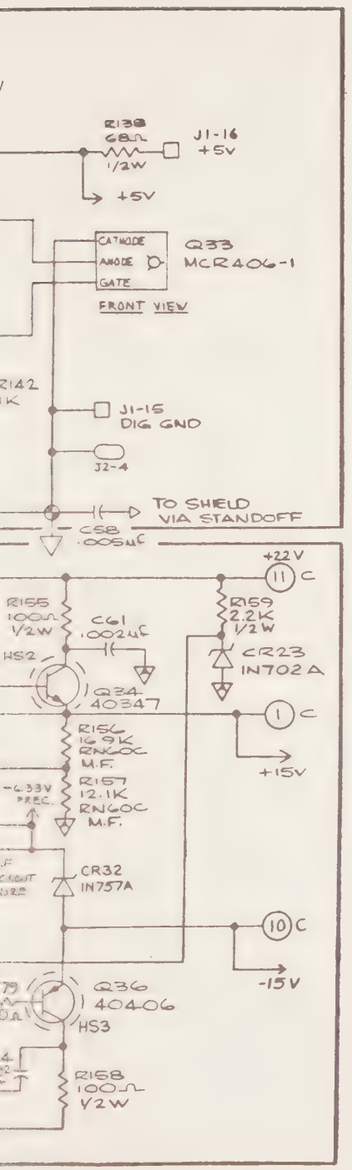
OVERLOAD

DIGITAL POWER SUPPLY

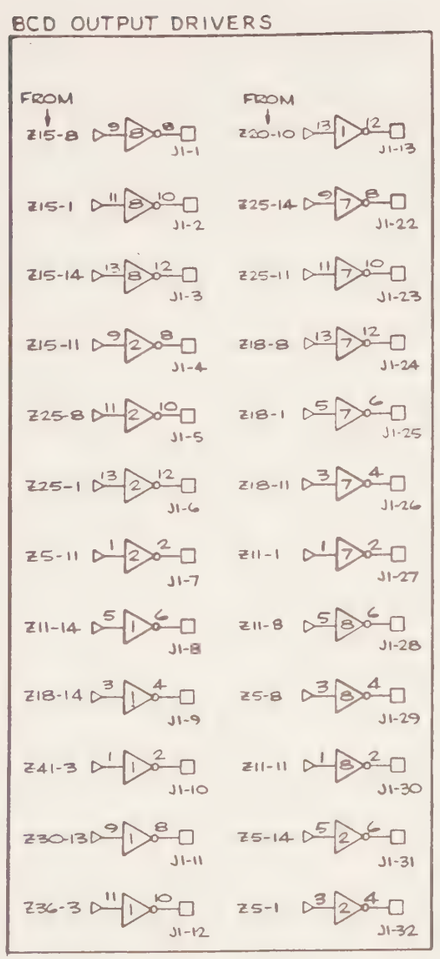
ANALOG POWER SUPPLY

12. ⎍ DENOTES INSULATED JUMPER
11. ○ INDICATES WIRED CONNECTIONS TO J2.
10. ALL OP-AMPS ARE 741C
9. ALL NAND GATES ARE 7410
8. ALL FLIP-FLOPS ARE SN74107
7. ALL NOR GATES ARE 7402
6. ALL HEX INVERTERS ARE MC837
5. ALL TRANSISTORS ARE 2N3393
4. ALL DIODES ARE IN914
3. ALL WIRE-WOUND (W.W.) ARE .05%, ± 10 PPM
2. ALL METAL FILM (M.F.) RESISTORS ARE 1%, R
1. ALL RESISTORS 1/4 W, 5% CARBON

NOTES: UNLESS OTHERWISE SPECIFIED



BCD OUTPUT DRIVERS



OUTPUT CONN. - PIN ASSIGNS.

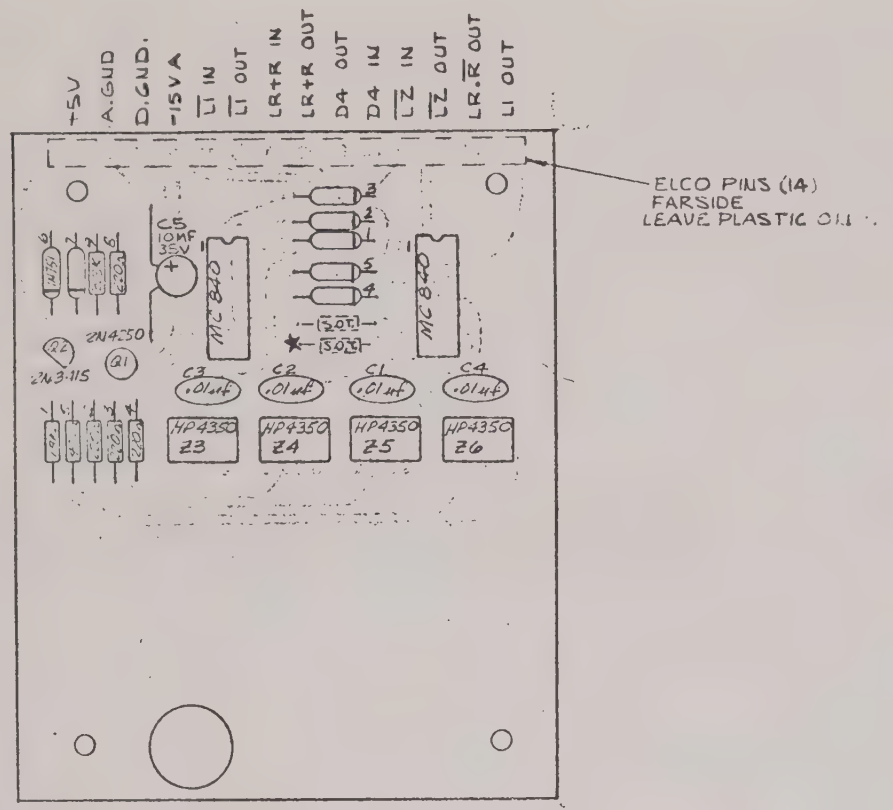
(AMPHENOL #57-40360)

J1

1	80
2	10
3	20
4	40
5	8000
6	1000
7	4
8	2
9	200
10	1000 (OVERFLOW)
11	OVERLOAD
12	(-)SIGN
13	SAMPLE COMPLETE
14	DECIMAL POINT
15	DIGITAL GND
16	+5V
17	(RESERVED FOR OPTIONS)
18	DISPLAY BLANKING
	COMP SIDE
	CIRCUIT SIDE
19	(RESERVED FOR OPTIONS)
20	HOLD
21	SAMPLE COMMAND
22	2000
23	4000
24	800
25	100
26	400
27	1
28	8
29	.8
30	4
31	.2
32	.1
33	ANALOG OUTPUT - SIGNAL
34	ANALOG OUTPUT - GROUND
35	
36	

19. GROUNDING KEY: ▽ DIGITAL GND; ⩛ ANALOG GND; ⩛ SIGNAL GND.
18. ALL POTENTIOMETERS ARE 15 TURN, CERMET, 3/4 IN. BODY.
17. "PER TABLE" REFERS TO TABLE 350-610-XX.
16. "⏚" DENOTES PROGRAMMING FEEDTHRU. SEE 350-610-XX FOR PROGRAMMING.
15. "D.M." DENOTES DURMICA CAPACITOR.
14. ALL POLYCARBONATE CAPACITORS ("P.C.") ARE ±10% TOL., 50 WVDC
13. ALL CAPACITORS ARE DISC, 500 WVDC MIN.; UNITS IN µF.

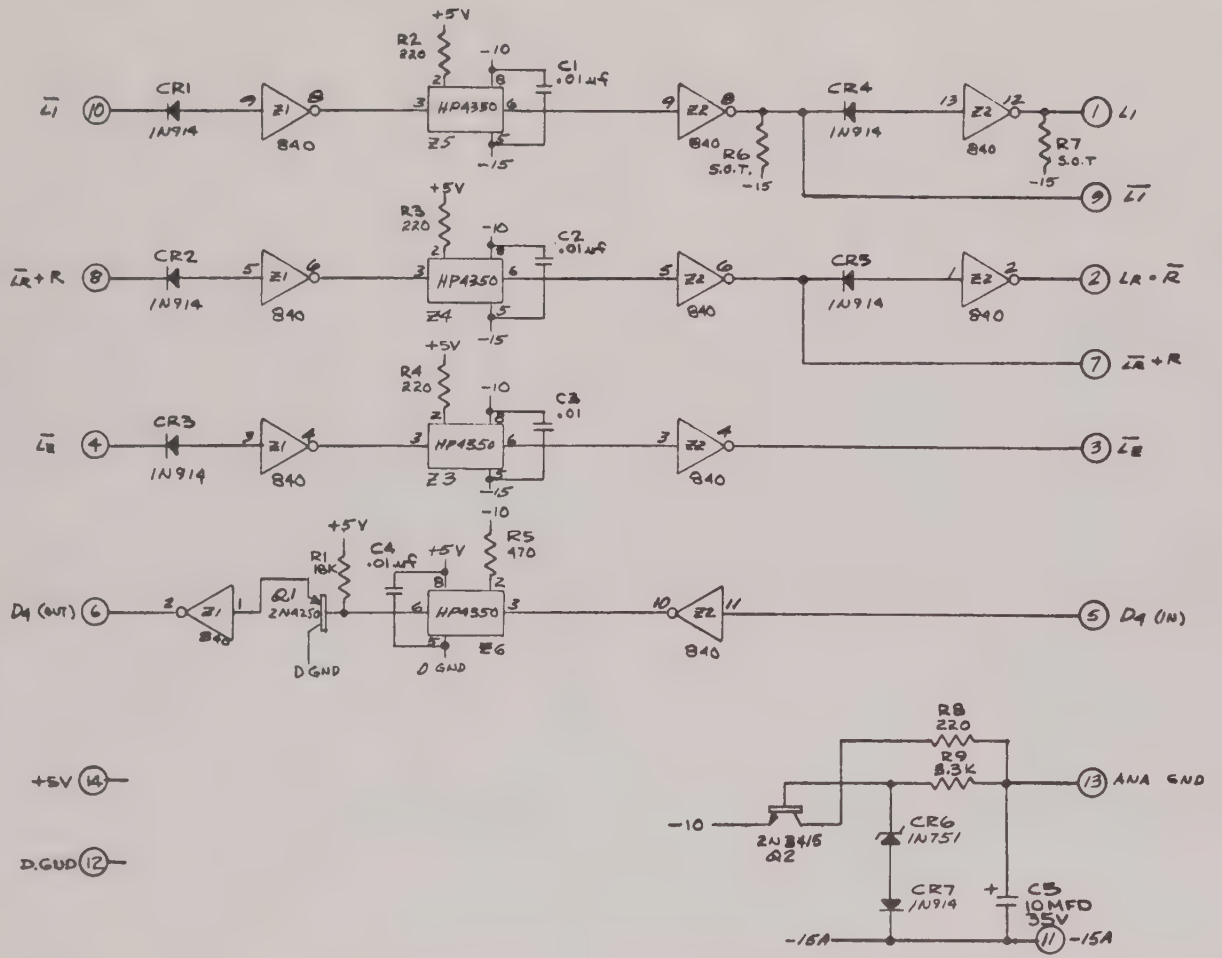
DS-350
SCHEMATIC 350-600-09



NOTES (UNLESS OTHERWISE SPECIFIED)

1. (•) INDICATES PIN 1 ON I.C. & CATHODE END OF DIODE.
2. DIODES IN914
3. * INDICATES FEEDTHRU.

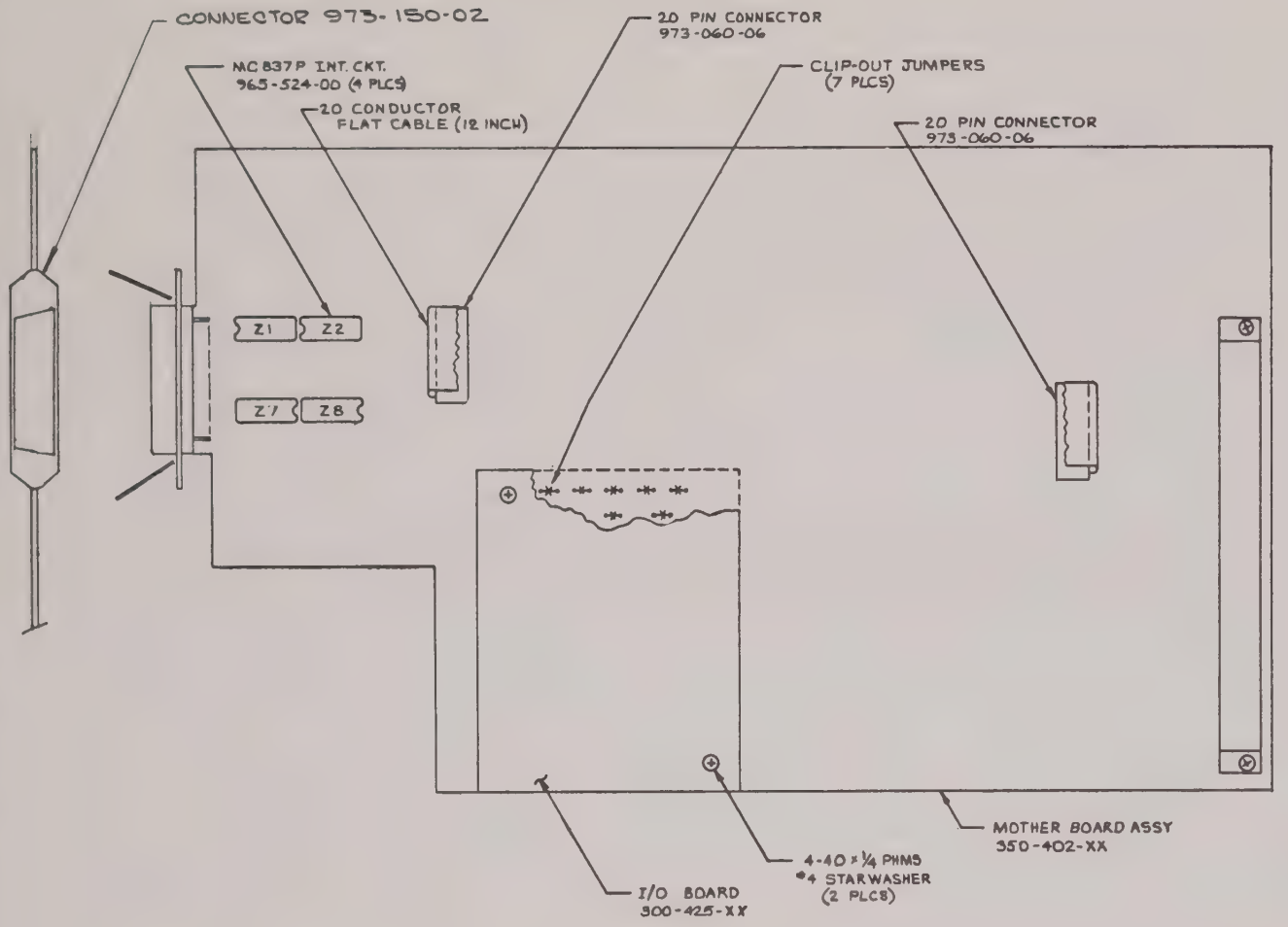
ISOLATED BCD OUTPUTS,
OPTION S6P
ASSEMBLY 300-425-10



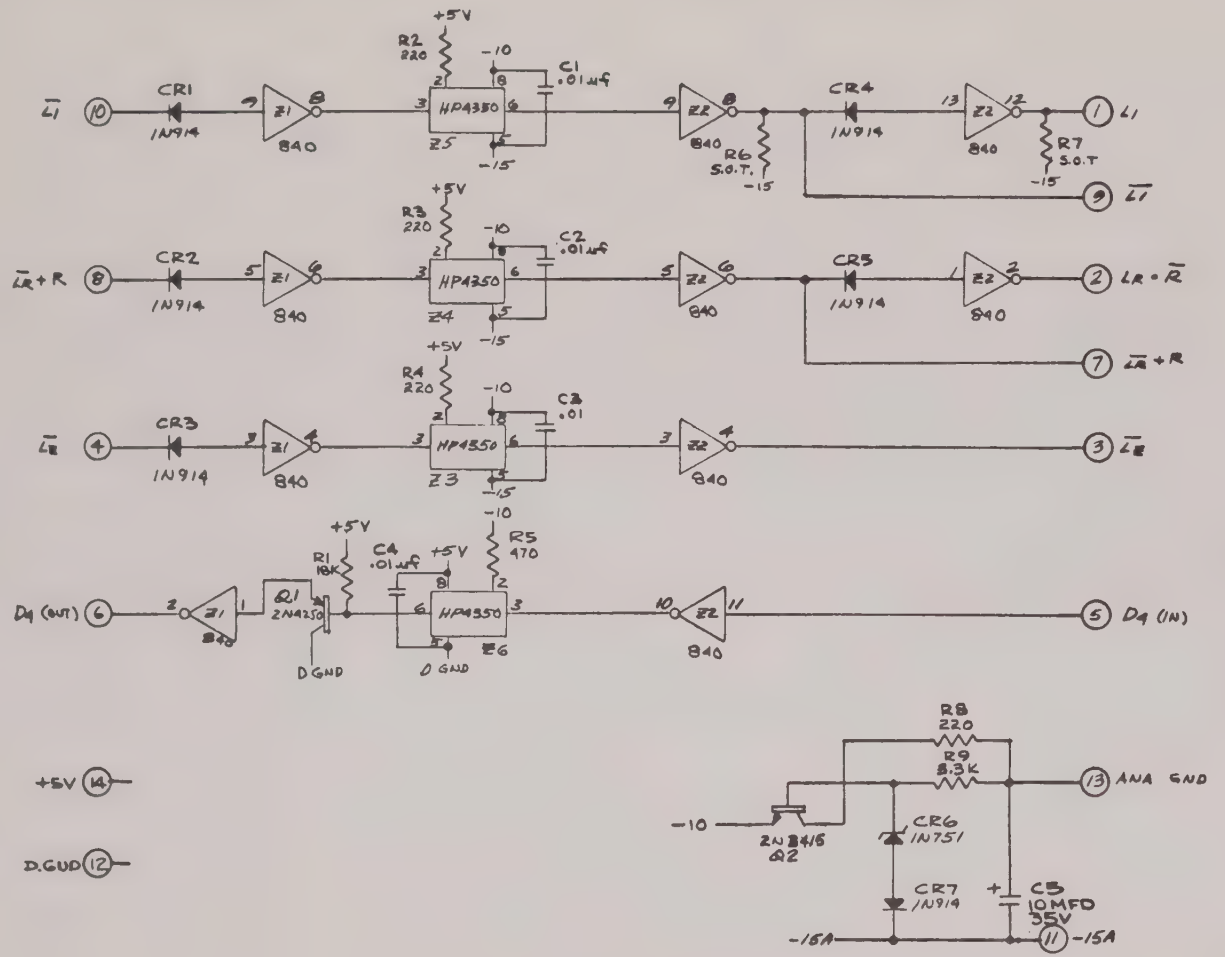
NOTES:

1. Z1, PIN 7 D GND, PIN 14 +5V
2. Z2 PIN 7 -15V, PIN 14 -10V

ISOLATED BCD OUTPUTS,
OPTION S6P
SCHEMATIC 300-625-07



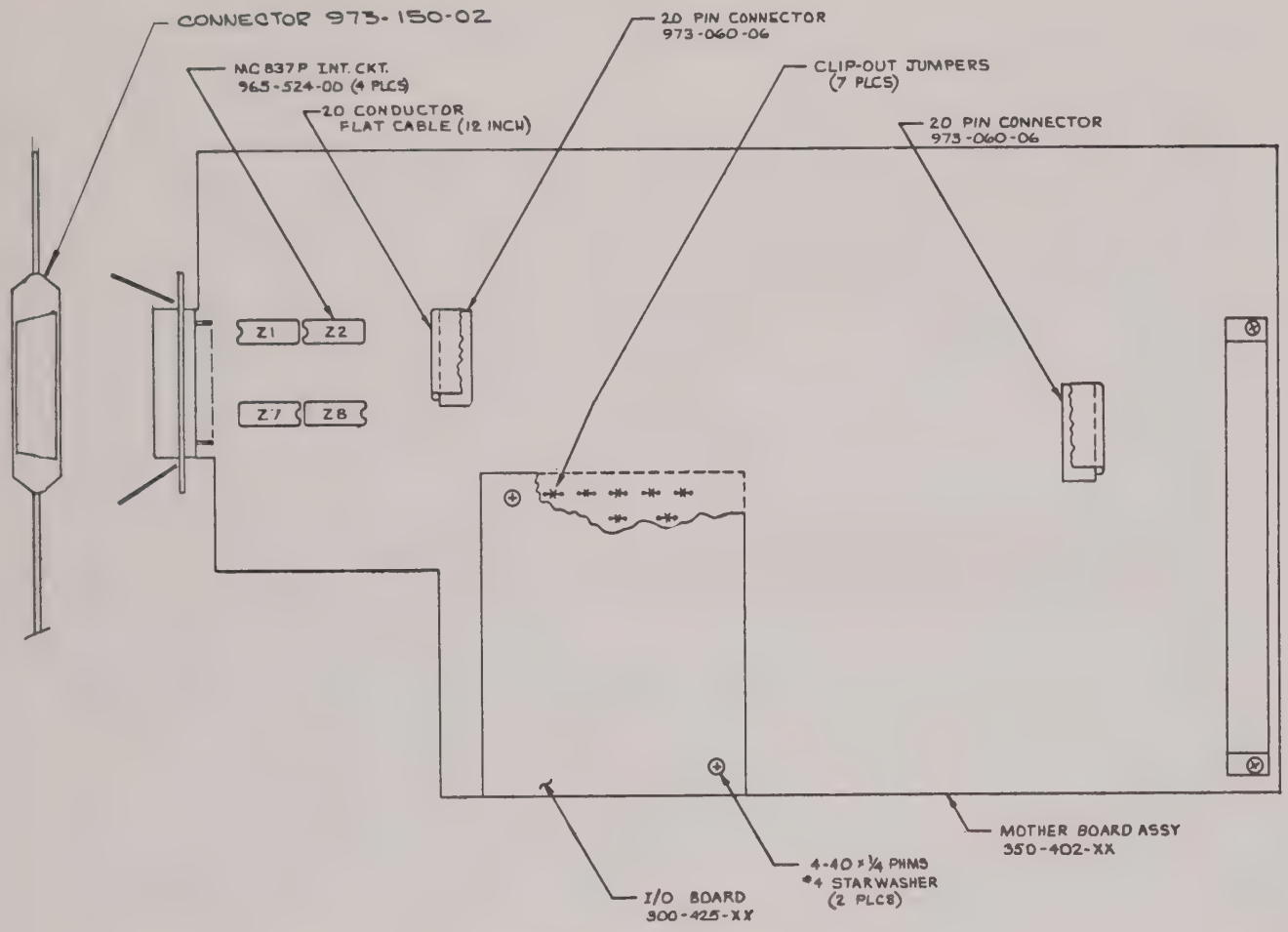
BCD OPTION, DS-350
ASSEMBLY 350-405-02



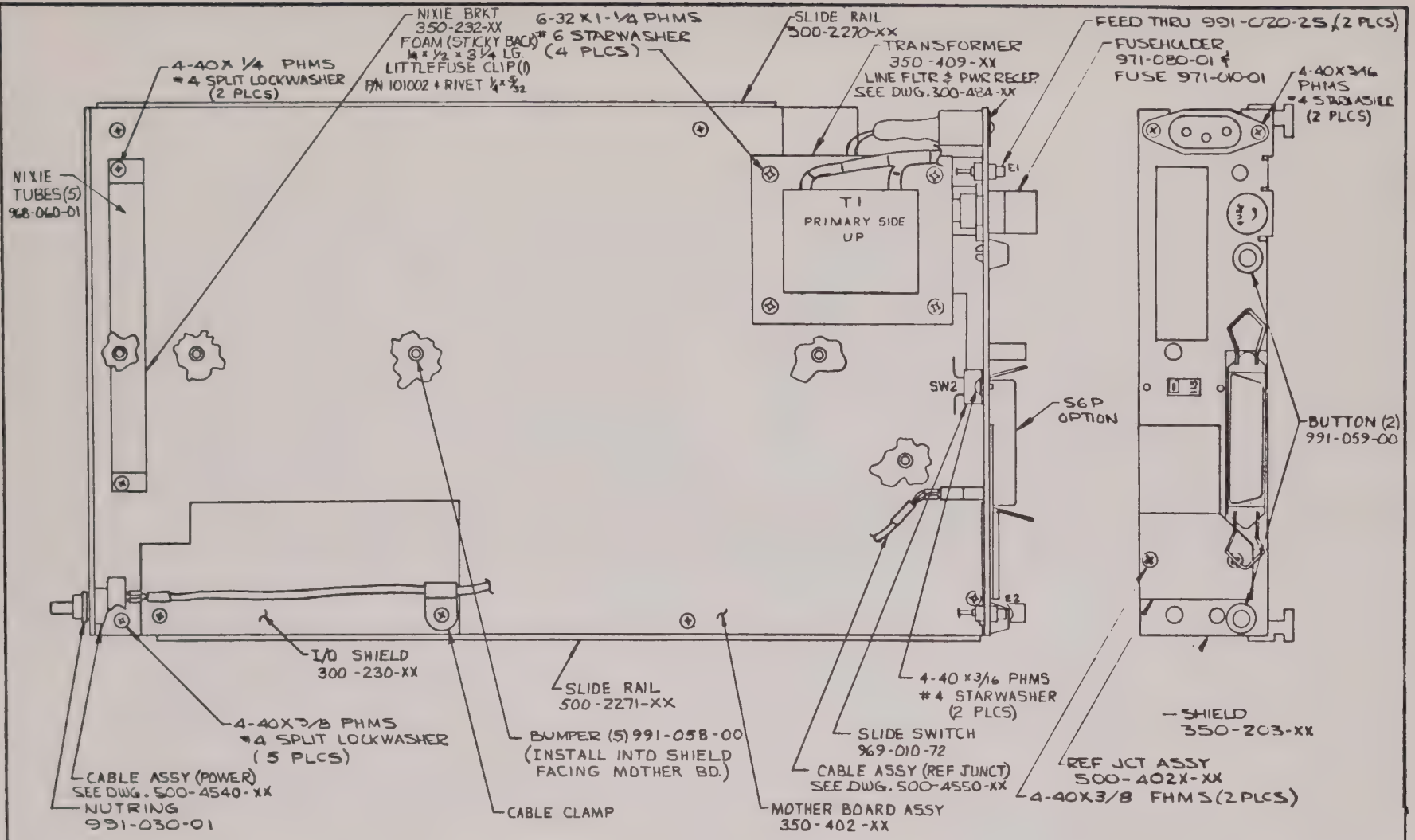
NOTES:

1. Z1, PIN 7 D GND, PIN 14 +5V
2. Z2 PIN 7 -15V, PIN 14 -10V

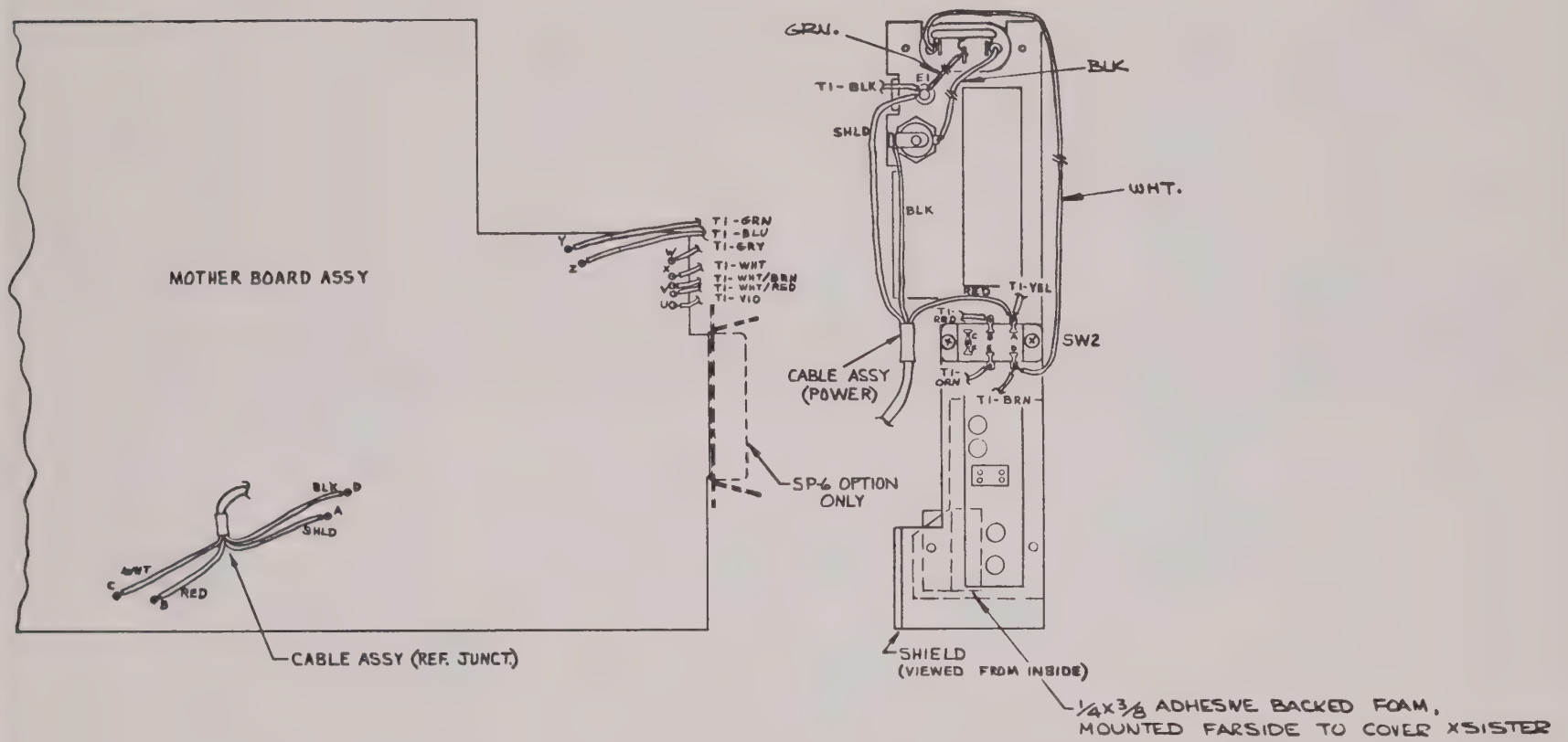
ISOLATED BCD OUTPUTS,
OPTION S6P
SCHEMATIC 300-625-07



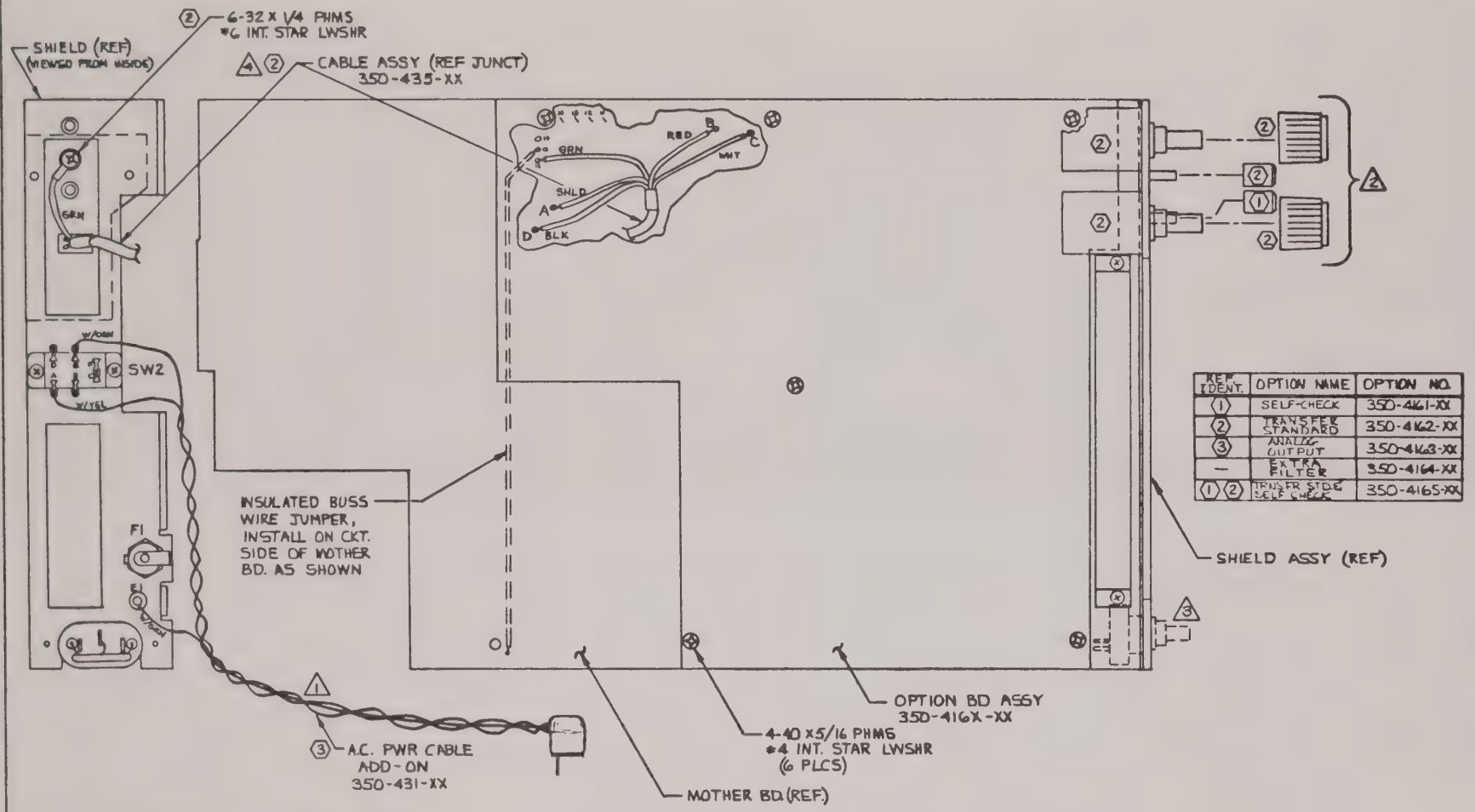
BCD OPTION, DS-350
ASSEMBLY 350-405-02



SHIELD ASSEMBLY, DS-350
SHEET 1 OF 3
ASSEMBLY 350-406-04



SHIELD ASSEMBLY, DS-350
SHEET 2 OF 3
ASSEMBLY 350-406-04



REF IDENT.	OPTION NAME	OPTION NO.
1	SELF-CHECK	350-4161-XX
2	TRANSFER STANDARD	350-4162-XX
3	ANALOG OUTPUT	350-4163-XX
—	EXTRA FILTER	350-4164-XX
1 2	TRNSFR STDRD SELF CHECK	350-4165-XX

5. IF EXTRA FILTER IS ONLY OPTION SPECIFIED USE ASSY 350-425D-XX IN PLACE OF 350-416X-XX.

4. STANDARD REF. JUNCT. CABLE (500-4650-XX) IS REPLACED WITH CABLE ASSY 350-435-XX WHEN TRANSFER STANDARD OPTION IS INSTALLED.

3. WHEN TRANSFER STANDARD OPTION IS INSTALLED, PWR SWITCH IS MOUNTED IN LEFT UPPER CORNER, OTHERWISE IT IS MOUNTED IN RIGHT UPPER CORNER.

2. BUTTONS AND KNOBS ARE INSTALLED AFTER FRONT PANEL IS MOUNTED.

1. AC. PWR CABLE ADD-ON WIRING IS IN ADDITION TO OTHER WIRING. (SEE 350-406-XX)

NOTES:

SHIELD ASSEMBLY, DS-350
SHEET 3 OF 3
ASSEMBLY 350-406-04

MANUAL ADDENDA

This package of addenda is a supplement to the Model DS-350, Digital Thermocouple Indicator, Owner's Manual

Included are:

350-4380-00	Self Calibration Option
350-4390-01	Temperature Transfer Standard Option
350-4400-00	Analog Output Option
350-4410-00	Extra Filter Option
350-416X-05G	Option Board Assembly
350-6160-03D	Schematic Options